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THE AMATEUR MECHANIC

THE AMATEUR MECHANIC

A PRACTICAL GUIDE FOR THE HANDYMAN

EDITED BY

BERNARD E. JONES

EDITOR OF "WORK"

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Contents

Wireless Telegraphy: Principles and Apparatus

Introduction.—Wireless telegraphy is the name given to a method or system of transmitting intelligence electrically from one point to another by means of a code of signals, without the aid of any connecting wires as employed in the ordinary "line" telegraph systems. As practically any method of signalling through space without the aid of intervening wires might be termed "wireless" telegraphy the distinguishing title of radio-telegraphy is to be preferred. The term "wireless telegraphy" is, in fact, something of a misnomer, as, though no wires are used connecting the transmitting station to the receiving station, still, at each station, wire is used, and in large quantities, as will be seen later.

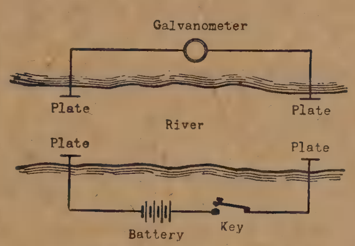


Fig. 1.—Diagram Showing Morse's Conduction System of Wireless Telegraphy

Different experimenters have tried to achieve the desired end by various means, and the methods employed may conveniently be classed under the following headings: (1) Conduction systems; (2) Induction systems; (3) Radiation systems. In the first section can be included all attempts to substitute either the earth or bodies of water in place of the connecting wires. The second section includes those methods that employed the phenomenon known as induction; and in the last section are all the present-day systems, which depend for their success upon the property possessed by the ether which enables it to act as a medium for the radiation of electro-magnetic waves produced by electrical oscillations in the aerial of the transmitting station.

These last-named systems have superseded all the others, being now used commercially all over the world.

A brief description of the earlier systems will be given as they are of some historical interest, in addition to which the reader will be enabled to follow the development of the science from the commencement right up to the present day.

Conduction and Induction Systems.—S. F. B. Morse, the inventor of the telegraph and of the "Morse" code, made experiments, early in the nineteenth century, with a view to signalling across a river without any connecting wires.

The method adopted was to sink two metal plates in the water at each side of the river, the two plates on one side being connected to a battery, and the two on the other side to a galvanometer.

Results were obtained, but it would appear that only a short distance could be successfully signalled across in this way, and that the size of the plates and the distance separating the two plates on the same side of the river had a considerable effect. Fig. 1 shows the method adopted in this experiment.

In the year 1886, Edison patented a system of inductive telegraphy for effecting communication with moving trains, the inductive effect taking place between a large metal plate on the roof of the railway carriage and the ordinary telegraph wire running alongside the track.

Sir William Preece, of the British Postal Telegraphs, conducted numerous experiments of a similar kind, and succeeded in

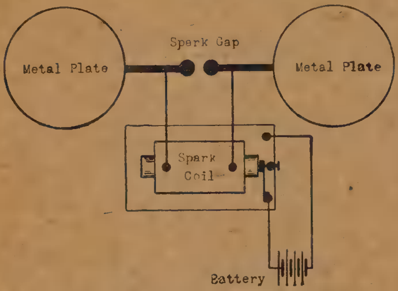


Fig. 2.—The Hertz Oscillator

signalling across the mouth of the River Severn, a distance of about five miles.

He employed two lengths of about 12 miles of wire, erected upon telegraph poles on each bank of the river, and the inductive effect caused by current flowing in one wire was detected in a telephone receiver suitably connected to the wire on the opposite bank.

The use to which these two systems (the conduction and the induction systems) were capable of being put was found to be very limited, the signalling distance being so short and the necessary apparatus and the space occupied by it (particularly the great lengths of wire) being out of all proportion to the distance signalled across.

Radiation Systems.—These depend for their action upon the following: (1) Properties of the ether; (2) Electro-magnetic waves; and (3) Electrical oscillations.

The Ether.—The name "ether" has been given to that invisible, intangible substance, or form of substance, which pervades all matter and all space, and which possesses the ability to act as a medium for the propagation of electro-magnetic waves. For instance, light is transmitted to our earth from the sun through spaces which, as far as is known, are not occupied by air or any tangible matter. Therefore, scientists infer that this light is transmitted through the medium ether, in the form of waves, and they think that a close relationship exists between electric waves and light waves, since, for one thing, their velocities are practically the same—namely, 186,000 miles per second. This is the velocity with which electro-magnetic or "wireless" waves travel through the ether.

Electro-magnetic Waves.—A current of electricity flowing in a wire or other conductor causes an electro-magnetic field, which surrounds the conductor, and, if the strength of the current is increased, the field around it increases also, the lines of force spreading out from the conductor.

If the current be now decreased, the lines of force contract and close in around the conductor. At the same time, electro-static strains are set up between conductors of opposite polarity; in the case of an "aerial system" forming part of a complete transmitting station, they are set up between the overhead aerial wires and the earth beneath. So that at each increase and decrease in the current both electro-magnetic and electro-static strains are set up in the medium surrounding the conductor (or aerial).

If, however, the increase and decrease of the current take place with extreme rapidity, some of the energy radiates off from the conductor in the form of electric waves. Waves created in the ether in this way are called electro-magnetic or Hertzian waves (the latter being named after the scientist, Hertz), and in radio-telegraphy are produced by a very high frequency—an oscillating current due to the discharge of a condenser.

Electric Oscillations.—If a charged condenser or Leyden jar is discharged through a circuit of low resistance, such as a few turns of thick wire, the discharge will consist of a number of very rapid oscillations ; the condenser overdischarges itself at the first rush and charges itself up the opposite way, the current surging to and fro in the circuit until the energy of the original charge is exhausted. The oscillating discharge of a condenser provides, therefore, a convenient method of producing in a conductor a current the strength of which fluctuates from a minimum to a maximum with great rapidity, which is exactly what is required to produce electro-magnetic waves. It remains to show how this principle has been developed, and how it is applied to the present-day wireless station.

In the year 1888, Hertz carried out a series of experiments which might be said to be the beginning of radio-telegraphy. To create electric waves, he employed the apparatus shown in Fig. 2, which is now known as a Hertz oscillator. A resonator (Fig. 3), consisting of a loop of wire provided with two brass knobs, between which was a minute gap, was employed to detect the presence of the electric waves. The two metal plates of the oscillator (see Fig. 2) possess a certain dielectric capacity, and act as a condenser with very wide air-space ; when charged to a high potential by the coil the resistance of the gap breaks down and an oscillatory discharge takes place, causing electric waves (or electro-magnetic waves) to be radiated off into the ether. Hertz found that by holding the loop of wire, or resonator, in the vicinity of an active oscillator, it absorbed sufficient of the radiated energy to cause small sparks to cross the gap between the brass knobs.

"Tuning" and "Resonance."—The efficient operation of wireless apparatus, especially as regards "selectivity" or prevention of interference, depends largely upon use being made of the principles of "tuning" and "resonance."

By "tuning" is meant the determination of the frequency, and consequently of the length, of the electro-magnetic waves to be radiated from a transmitting station or received at a receiving station.

By "resonance" is meant the adjustment of one circuit to have the same frequency as another circuit, such two circuits being, for example, the aerial circuits at a transmitting and receiving station respectively.

A frequently observed illustration of resonance occurs when some ornament in a room gives forth a "singing" or jarring sound when a certain note on the piano is struck. Only the one particular note on the piano produces this effect upon the ornament in question, due to the natural frequency of vibration of the ornament corresponding to that of the note sounded. In other words, the two are in resonance.

Fig. 3.—Resonator for Detecting Presence of Electric Waves

In wireless telegraphy, tuning and resonance apply particularly to circuits known as *oscillatory circuits.* Any circuit possessing inductance and capacity and having a low resistance is an oscillatory circuit.

A charge of electricity given to such a circuit sets up oscillatory currents in the circuit, which swing to and fro until the energy is dissipated by, for one thing, the resistance of the circuit and, for another, by radiation in the form of electro-magnetic waves.

Inductance may conveniently be considered as the electrical equivalent of inertia in mechanics, that is, opposition to change of motion, whilst *capacity* means ability to hold or store an electro-static charge.

Oscillatory Circuits.—There are two varieties of oscillatory circuits, (1) the

closed oscillatory circuit in which the inductance and capacity are concentrated in a coil of wire and a condenser respectively, and (2) the open oscillatory circuit, in which the inductance and capacity are more or less spread over the circuit as in the case of an aerial system having inductance in itself by reason of the length of wire and distributed capacity to earth owing to its position with regard to the ground below, the air between acting as dielectric.

The oscillation frequency of such circuits depends upon the values of the inductance and capacity. Currents will swing to and fro more slowly in a circuit having large capacity and inductance values than in a circuit having smaller values.

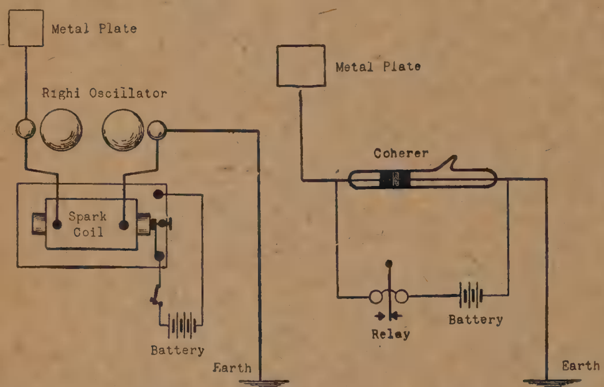


Fig. 4 Fig. 5

Figs. 4 and 5.—Diagrams of Marconi's Early Transmitting and Receiving Stations Respectively

The Hertz oscillator, as a means of producing and radiating electric waves, is practically an *open* oscillating circuit (or radiating circuit), the two metal plates placed widely apart performing functions in every way similar to the "aerial" and "earth" of the present-day wireless transmitting station.

An improved oscillator was subsequently devised by Prof. Righi, in which two larger metal spheres were used in conjunction with the two as employed in the Hertz oscillator, the former being immersed in oil so that the spark, when it occurred, had to take place in the oil.

The Hertz resonator, as a means of detecting electric waves, is practically a *closed* oscillating circuit, being similar, in principle at any rate, to the closed circuit of present-day receiving apparatus.

Other scientists have contributed in larger or smaller degree to the advancement of the science, notably, M. E. Branly (who invented the filings type of coherer, a great improvement upon the Hertz resonator for the detection of electric waves) and Sir Oliver Lodge (who has made many improvements, particularly with regard to the tuning or syntonising of the various circuits).

The Marconi Coherer.—Guglielmo Marconi, an Italian electrical engineer, first became interested in Hertzian waves when a student under Prof. Righi, and later he brought his ideas to England and laid them before Sir Wm. Preece, of the British Postal Telegraphs, who gave him every encouragement. In his early experiments he used the Righi oscillator, with metal plates as capacity areas, and the Branly filings-type coherer; but later he devised a new type of coherer (shown in Fig. 5), now known as the Marconi coherer. This consists of a small glass tube provided with two tightly fitting silver plugs, adjusted until a distance of about one-sixteenth of an inch separates them, the space between them being filled with a mixture of nickel and silver filings and the tube exhausted of air and sealed up. This he used in conjunction with a relay and recording mechanism operated by local batteries, and he succeeded in obtaining a written or printed record of the dots and dashes transmitted by the oscillator.

As increased signalling range was found to be obtained by increasing the size of the capacity areas (in this case the metal plates), and the distance separating them, it occurred to Marconi to substitute the earth for one of the plates and raise the other plate to a considerable height to

increase the distance between them. Figs. 4 and 5 show this arrangement as adopted at the transmitting and receiving stations respectively.

After trying this, Marconi became convinced that the increased effectiveness was due to the length of wire, and not to the plate at the end of it, so he dispensed with the plate and used only the wire, which became known as the " aerial " or " antenna." The aerials in use now are just modifications of this original idea with the number of wires increased to two, four, six, or, in high-power commercial stations, to a perfect network of wires.

Numerous improvements have been made in both the transmitting and receiving apparatus, with a view to obtaining increased range and greater selectivity, the latter being accomplished by means of various devices to permit of more exact tuning or syntonising of the different circuits and of one station to another as regards wave-length, thus minimising interference by undesired stations.

A Simple Analogy.—Before considering the action of typical transmitting and receiving stations, a simple mechanical analogy will be given illustrating several important points and, it is hoped, making subsequent explanations of wireless circuits and phenomena more readily understood.

Sound Signals.—Suppose two stations about a mile apart, and a steam whistle to be blown at one of them. The consequent disturbance in the air travels outward from the point of disturbance in the form of sound waves, and the passing of some portion of the waves over the distant station can be detected by " sense of hearing " of a person at that point.

It will be obvious that the strength of the received sound, neglecting losses in transit, will depend principally upon the strength or amplitude of the disturbance caused by the transmitter (the whistle), and the pitch of the note heard at the receiving station will depend upon the number of waves per second striking the eardrum of the person at that point, which is equal to the number of waves or disturbances at the transmitter.

This " number of waves per second " is known as the *frequency*. It will be seen that on the frequency and velocity (that is, rate of travel) depends the distance between any two successive waves. This distance, measured between two points of corresponding amplitude in any two successive waves, is known as the " wave-length," and is noted by the symbol λ (lambda).

The diagram (Fig. 6) will, it is thought, make clear exactly what is meant by amplitude (a) and wave-length (λ).

It is also to be noted that frequency (f) and wave-length (λ) vary *inversely*, that is to say if (f) be doubled, (λ) will be halved.

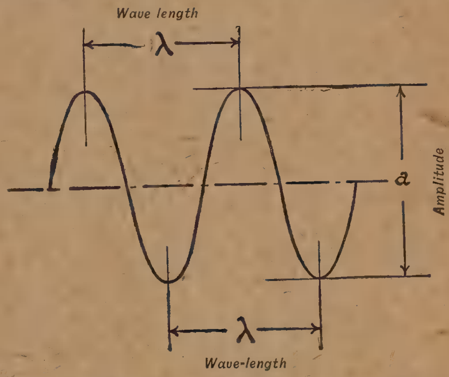


Fig. 6.—Diagram Illustrating Terms Wave-length (λ) and Amplitude (a)

The velocity (v) depends upon the medium through which the waves are propagated ; in the case of sound waves through air it is approximately 1,100 ft. per second. The relationship between these values is expressed as follows :

$$\text{Frequency (f)} = \frac{\text{Velocity (v)}}{\text{Wave-length } (\lambda)} \text{ or}$$

$$\text{Wave-length } (\lambda) = \frac{\text{Velocity (v)}}{\text{Frequency (f)}}$$

Suppose, for instance, in the foregoing analogy the pitch of the note emitted by the whistle corresponded to the middle C of the piano, the frequency of which is approximately 260 per second ; then from the above expression,

$$\text{Wave-length (in feet)} = \frac{1{,}100 \text{ (feet per sec.)}}{260}$$

$$= 4.23 \text{ feet.}$$

"*Wireless*" *Signals*.—The reader will profit from this simple analogy in which the action can readily be visualised, as it were, by substituting the following.

Two stations, say 100 miles apart, are each provided with an electrical conductor in the form of a wire or series of wires known as the "antenna," or aerial, suitably held aloft and carefully insulated. At the transmitting station apparatus is provided by means of which electrical currents at a pre-determined and definite frequency are made to flow in the aerial system.

The surging to and fro, or "oscillating," of the current in the aerial sets up in the surrounding ether electro-static strains which give rise to electric waves radiating from the aerial in all directions with the speed of light, namely 186,000 miles or 300,000,000 metres per second.

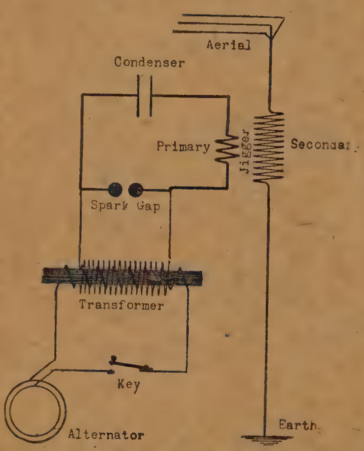


Fig. 7.—Diagram Showing the Essentials of a Complete Transmitting Station

Oscillatory currents in the aerial wire thus cause the radiation of electric waves through the ether, and, conversely, electric waves impinging upon an aerial wire set up oscillatory currents in that wire.

So at the receiving station, the aerial wire is connected to suitable instruments (to be described later) and the oscillatory currents set up in this aerial by the incoming waves are made to indicate their presence—usually by means of sounds produced in a sensitive telephone receiver.

The statement or formula as quoted above in the case of the sound waves remains true, but the velocity (v) will now have a different value, namely 300,000,000 metres per second, so that in the practical case of a vessel or shore station fitted with a wireless installation and adjusted ("tuned," as it is termed) to radiate waves 300 metres in length, the frequency of such waves (and of the oscillations causing them) will be:

$$\text{Frequency (f)} = \frac{\text{Velocity(v) metres per sec.}}{\text{Wave-length }(\lambda)\text{ metres}}$$

$$= \frac{300{,}000{,}000}{300} = 1{,}000{,}000 \text{ per sec.}$$

An exact comparison cannot be made between the mechanically produced sound waves and the electrically produced "wireless" waves.

A brief explanation will now be given of the means by which the essential operations are carried out in practice, namely, the method of charging and discharging at the transmitting station and the detection of incoming waves at a receiving station.

Transmitting.—Electric current from an alternator, driven by an electric-motor, gas-engine, etc., is led to the primary terminals of a static transformer, from the secondary terminals of which the "transformed" current, at a pressure of from 20,000 to 50,000 volts, is led to a spark gap, in series with which are connected a high-tension condenser, and the primary of an oscillation transformer consisting of a few turns of very thick wire, or stranded cable. The oscillation transformer is commonly referred to as a "jigger." In the proximity of the latter are a number of turns of slightly smaller wire, or cable, known as the "jigger" secondary, the position of which, with regard to the primary, is capable of being altered so that the degree of coupling between the two can be varied. One end of the wire forming the "jigger" secondary is connected to earth and the other to the aerial. The arrangement is shown diagrammatically by Fig. 7. The end of the secondary coil which is connected to the aerial is usually connected thereto through further turns of wire, known as

the aerial tuning inductance, the purpose of which is to alter the wave-length of the aerial by altering the number of turns included in the circuit. This is not shown in the illustration. The signalling key is shown inserted in the circuit between the alternator and the primary of the static transformer, but in some instances it is inserted in the transformer secondary circuit.

There are numerous other devices, not here enumerated, which increase the general efficiency, but the above description and diagram include the essentials, and the action is as follows: When the sending key is depressed, current from the alternator flows into the transformer, and high-potential current from the transformer secondary flows into the high-tension condenser until a potential is reached at which the insulation resistance of the spark gap breaks down. Immediately this occurs an oscillatory discharge takes place, the condenser discharging across the gap, and the current surges to and fro in the circuit formed by the condenser, spark gap and jigger primary until the charge is exhausted. All this, of course, takes place in a minute fraction of a second, so that to the eye, the discharge appears to consist of only one spark. From the jigger primary, current is transferred to the jigger secondary by induction, and the aerial becomes charged with an oscillating current, causing electric waves to be radiated off into the ether.

Receiving.—A portion of the electric waves radiating from the aerial of the transmitting station impinge upon the aerial of a receiving station and induce oscillations in it. This oscillating current is led through a coil of wire, the number of turns of which can be varied by means of a suitable switch, to earth. By means of this coil of wire, which is known as the tuning-coil primary, the wave-length of the aerial can be varied; and the electric waves from the transmitting station will produce a maximum effect when the wave-lengths of both aerials are identical.

The tuning-coil primary is in inductive relation with a coil of finer wire known as the secondary; and the oscillating current flowing in the former induces a current in the latter. In this case, also, the maximum effect will be produced when the two circuits are in the resonance or "in tune."

These two coils (primary and secondary) are together known as a receiving oscillation transformer, or receiving jigger, but the wires of which they are constructed need not be thick as in the case of the transmitting jigger, as only a minute quantity of current has to be carried.

To make the very minute quantity of current in the secondary of the receiving jigger give audible signals, a sensitive telephone receiver is employed in conjunction with some form of "detector." There are many types of detectors—magnetic, crystal, electrolytic, etc.—about which a great deal might be written, but it is not the present intention to enumerate and describe them, as to do so would take up too much space.

The Crystal Detector.—The action of one particular type, however, will be described now, namely, the "crystal" detector, as this is a type much used by amateur experimenters. The crystal detector consists essentially of a contact between either two particular crystals, or a metal point and a crystal; and its purpose is to rectify, at the point of contact, oscillating or alternating current and make it into uni-directional or direct current.

It should here be said that the three-electrode thermionic valve is purposely omitted at this point, as this piece of apparatus is considered of sufficient importance to warrant special attention. A brief outline of the theory together with practical details regarding the construction and operation of apparatus employing a valve as a detector will be found later in this chapter.

The frequency of the oscillatory currents in the receiving apparatus is very high (as already explained), so that the telephone diaphragm cannot possibly respond to them and, even if it could, the human ear could not detect the vibrations emitted. But the crystal detector, possessing the property of permitting current to flow only in one direction across

the point of contact (a property known as "uni-lateral" or "uni-directional conductivity"), converts the oscillatory currents into uni-directional impulses which are passed through the windings of the telephone receiver.

These impulses, however, are too rapid to impart separate movements to the telephone diaphragm. Instead, they have a cumulative effect, and all the rapidly succeeding impulses of each group of oscillations due to a single spark at the distant transmitter cause only one deflection of the diaphragm and, as the number of "groups" per second depends only upon the rate of sparking at the transmitter, the note emitted by the receiving telephones is equal in frequency (or pitch) to the spark note of the transmitting set.

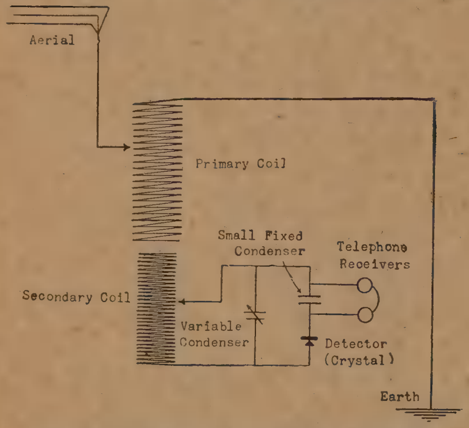


Fig. 8.—Diagram of Complete Receiving Station, Including a Crystal Detector

The detector and telephone receiver are connected either across the secondary of the receiving jigger, or in shunt to a variable condenser connected in parallel with it. This arrangement is shown in Fig. 8. Here, again, there are many further devices which make for greater efficiency, but the above description and diagram include the essentials.

Up to the present only those wireless "systems" which make use of a spark discharge as a means of producing oscillatory currents have been considered. Such systems are known as "spark" systems and, as the sparking is intermittent owing to the necessity of recharging the condenser to a high potential between sparks, electro-magnetic waves are radiated in "groups" with separating intervals, each group consisting of a number of complete waves which decrease in amplitude more or less rapidly, on account of which the waves are said to be "damped." Another name for such wireless systems therefore is the "damped-wave" systems.

Very important developments have taken place in connection with other forms of wireless transmitting apparatus capable of producing oscillatory currents and consequently electro-magnetic waves of constant amplitude (that is the waves do not die away or are not "damped"). Such waves are known as Continuous Waves.

The employment of continuous waves in conjunction with sensitive receiving apparatus of a special nature has greatly increased the signalling range of a transmitting set of given power input, whilst the very sharp tuning effects obtainable enormously minimise interference.

Four Types of Transmitting Apparatus.—For a transmitting station to be able to radiate continuous waves, it is essential that it should be equipped with some form of apparatus capable of producing oscillatory currents at a frequency corresponding to the length of the waves to be radiated.

Such apparatus may be one of the following four types, all of which have been, and still are, used in commercial working:

(1) *Arc sets*, in which an electric arc is formed between copper and carbon electrodes enclosed in a suitable gas-tight vessel containing hydrogen or coal gas. The ability of such an arc to maintain oscillatory currents of constant amplitude in an inductance-capacity circuit suitably connected to it is due to the fact that a decrease of current through the arc gives rise to an increased voltage across it and vice-versa, these fluctuations taking place at a frequency which is governed by the electrical constants of the oscillatory circuit. The arc is fed by direct

current and is made to take place in a strong magnetic field. In order to obtain the necessary oscillatory currents in the aerial system of the station, the arc itself may be inserted in the aerial circuit, suitable inductances being provided to effect tuning, and signalling is usually carried out by means of a key arranged so as to short-circuit certain turns of this inductance coil, thus effecting a change in the length of the waves radiated, the continuous oscillations being maintained by the arc without interruption. The two distinct waves radiated during operation are known as the "signalling" and "spacing" waves respectively. Apparatus of this description has been adopted by several wireless companies, and very powerful "arc" stations are now in daily use.

(2) A specially-designed *high-frequency alternator* capable of supplying, direct to an aerial system, oscillatory currents of the required frequency. Owing to considerations of speed of rotation versus high-frequency, combined with appreciable power, such machines are most suitable for use in stations arranged to radiate waves of considerable length and which, of course, do not require an extremely high-frequency current to be supplied to the aerial system.

(3) An arrangement of *spark-gaps and associated closed oscillatory circuits*, the sparks being made to occur consecutively at all the gaps in turn, thus producing an "overlapping" effect of the respective "groups" of oscillations, so that the resultant oscillations in the aerial and the radiated waves therefrom are practically continuous. This type of apparatus, also, can deal with large power and is employed in powerful trans-ocean stations in Great Britain and Norway.

(4) The fourth method of generating continuous oscillations in a suitable aerial system makes use of the special properties possessed by *thermionic valves* having three (sometimes more) electrodes. Thermionic valves (usually termed "valves") are probably the greatest modern development in wireless telegraphy.

The Thermionic Valve.—The "valve" consists essentially of a closed glass vessel exhausted to a high degree of vacuum and containing three elements or electrodes: (1) the "kathode," consisting of a filament of tantalum or tungsten capable of being heated to incandescence by the passage of an electric current from an accumulator or other source of low-voltage supply; (2) the "anode," consisting usually of a metal plate in the form of a cylinder surrounding, but at some little distance from, the filament or kathode; (3) the "grid," consisting of a perforated metal plate, cylinder of wire gauze, or sometimes merely an open spiral of wire occupying a position between the filament and the anode.

Briefly described, the action is as follows: The filament when heated by the passage of current emits negative charges of electricity ("electrons"). These electrons are affected by an electro-static field; in other words, they are attracted to a positively-charged body and repelled by a negatively-charged one. The anode (sometimes termed the plate or sheath) is connected to the positive pole of a battery whose negative is connected to the filament; it attracts the electrons more or less strongly according to the strength of the field, or, in other words, according to the potential to which the anode is charged.

A flow of electrons takes place therefore from filament to anode, which is equivalent to a flow of *current* from the anode battery to the anode and across the space in the valve to the filament.

The rate of flow of the electrons is governed by the intervening grid and its potential compared to that of the filament, so that the "grid-filament" circuit may be regarded as the input side, and the anode-battery-filament as the output side of a three-electrode valve.

The control exercised by the grid is very sensitive and a small change of grid potential with respect to the filament will produce a large change in the value of anode current (or electron flow). Further, it is possible by suitably coupling the respective circuits together (electro-magnetically or electro-statically) to arrange that variation of anode current due to an initial disturbance in the circuits (such as

the completion of the grid circuit by means of a Morse key) is made to effect a variation in grid potential and set up in the oscillatory circuit to which the anode is connected oscillations which are of very high frequency (termed radio-frequency), and which automatically persist as long as the correct adjustments and power supply are maintained.

If, therefore, the oscillatory circuit to which the anode is connected is a suitably proportioned aerial system, electro-magnetic waves of constant amplitude (continuous waves) will be radiated.

Receiving Continuous Waves.—In the reception of continuous waves, as there are no "groups" or "trains" of waves with separating intervals, simple rectification (as, for instance, with a crystal detector) will not answer owing to the entire absence of any variation at an *audible frequency*.

Continuous waves when received upon the suitably tuned aerial of a receiving station produce in the circuits of the receiver continuous oscillations at radio-frequency, that is, considerably above the limits of audibility apart from the question of the mechanical vibration of the telephone receiver diaphragms; such currents, if rectified, would merely cause a deflection of the telephone diaphragms when the first wave arrived and another deflection when the last wave ceased, even though the duration of the received waves was an hour or more. This, of course, being quite useless for Morse signalling between two stations, special means have had to be devised.

The Buzzer or Rotary Interrupter.—The first method adopted (before the introduction of three-electrode valves) consisted in mechanically interrupting the oscillatory current in the receiving apparatus, so producing an audible note at a frequency which depended only upon the rate of interruption. For this purpose a "buzzer" or rotary interrupter was introduced either in the aerial or closed circuit of the receiving gear and proved commercially successful.

Heterodyne and Autodyne Methods.—With the introduction of the "valve," however, there was developed a piece of apparatus capable of generating oscillatory currents at almost any required frequency—an extremely efficient method of receiving continuous-wave signals depending upon the "beats" produced by superimposed waves. The oscillations in a receiving set due to incoming continuous waves may have super-imposed upon them further oscillations *of a slightly different frequency*, these additional oscillatory currents being generated either in the receiving set itself or in a separate piece of apparatus employing a valve as a low-power generator. The effect is to produce variations in amplitude at a rate corresponding to the difference in frequency between the two sets of oscillations. This difference may readily be made small enough to give rise to variations in amplitude or "beats" at audible frequencies which are then rectified and caused to actuate the telephone diaphragms.

This method of reception is termed the "heterodyne beat" method, and if separate apparatus is employed to produce the local oscillatory currents such is termed a "separate heterodyne" whilst if the local oscillations are produced in the receiving set itself, such set is termed a "self-heterodyning receiver." Later usage is to term the former method the "heterodyne" and the latter the "autodyne" method.

Further considerations with regard to the arrangement and coupling of circuits for continuous-wave reception will be explained on a later page of this chapter when describing the construction of valve-type receiving apparatus.

Logical Sequence of the Information.—The valve apparatus to be described is such as may readily be used in conjunction with almost any type of receiving set or tuner; so, in order to present the practical constructional work in proper chronological order in accordance with the plan adopted up to this point, there will now be described:

(1) Simple receiving aerials suitable for erection by amateur experimenters and complying with the Regulations laid down by the Postmaster-General (P.M.G.).

(2) A 600/6000-metre crystal receiving set which may be constructed cheaply without the aid of special tools and which will receive wireless signals from numerous commercial wireless stations.

(3) A complete valve-detector unit, which may easily be used in conjunction with the above-mentioned receiving set for the reception of "spark" and continuous-wave (c.w.) telegraphy signals and wireless telephony.

(4) Some notes concerning radio-telephony.

(5) A list of some of the chief wireless stations, giving times of operation, wave-length employed, etc.

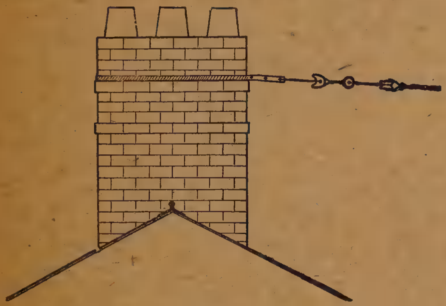


Fig. 9.—Aerial Chimney-attachment Consisting of Galvanised-iron Band Secured by Bolts and Nuts

AERIALS

The most important practical consideration is to obtain as great a length of wire as possible, suspended as high as possible above ground level, avoiding close proximity to earth-connected bodies (buildings, high trees, etc.), which have a screening effect.

Before the installation of a wireless receiving station is proceeded with, it is necessary to obtain an official Permit or Licence from the P.M.G. In addition to payment of a small annual sum there are certain conditions to be complied with, and a form giving full particulars may be obtained on application to the Secretary, General Post Office, London, E.C.

The conditions relating to aerials are as follows: Extreme height of aerial above ground not to exceed 100 ft.

Total length of wire which may be used, including the leading-in wire, 100 ft. for single-wire aerial and 140 ft. for aerials where two or more wires are employed (in the case of a two-wire aerial, 70-ft. of double wire).

Where an aerial is to be used for receiving purposes *only*, additional length of wire may be employed by special arrangement with the P.M.G.

The Single-wire Aerial.—For receiving purposes, a single wire will be found quite satisfactory and may consist of No. 14 or No. 16 S.W.G. hard-drawn copper, phosphor bronze or silicum-bronze.

Specially-made stranded wires, either bare or with each strand separately

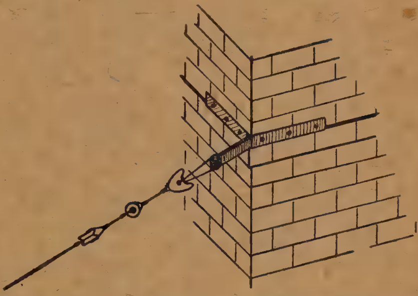


Fig. 10.—Corner-bracket Attachment for Chimney or Corner of Building

enamelled, are an advantage both electrically and mechanically.

When the erection of a receiving aerial is contemplated, the first thing to be done is to make a careful survey of the situation, noting especially: (1) The position, height and distance separating the highest available points, whether flag-poles, chimney-stacks or tall trees. (2) The relative position of the proposed instrument room, which, if possible, should be on the ground floor, and most convenient method of leading down from the aerial proper.

The down-lead should be taken either from one end of the horizontal part of the aerial or from *the exact centre*, and must not make an acute angle with the aerial.

Obtain the requisite length of aerial wire together with insulators and (if the aerial is being erected between chimney-

stacks), having received the necessary consent of the owners and tenants of the houses in question, provide and fix suitable fittings to which the aerial insulators may be attached.

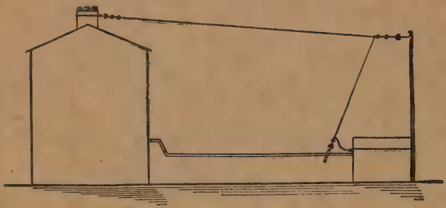


Fig. 11.—Inverted L-type Aerial, Single-wire

For chimney-stacks a light galvanised iron band, say 1 in. or $1\frac{1}{4}$ in. by $\frac{1}{8}$ in. in section, may be fitted right round the stack and secured by means of galvanised bolts and nuts, as shown in Fig. 9. Alternatively standard type corner brackets as used in the erection of telephone lines may be fitted, as in Fig. 10.

In order to secure efficient insulation, even under adverse weather conditions, it is advisable to employ several insulators connected in series, say three at least at

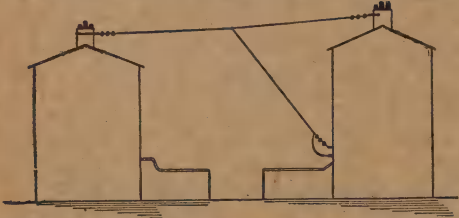


Fig. 12.—T-type Aerial, Single-wire, Showing Method of Securing Down-lead

each end of the aerial proper with a further three at the lower end of the down-lead. For this purpose, the reel or stirrup type of insulator has several advantages, namely, great mechanical strength, large exposed surface which minimises surface leakage when wet, high insulation value of material and, lastly, owing to the method of connecting up, the aerial wire does not fall should an insulator break, though this is an unlikely happening.

In general, aerials erected for use by amateur experimenters are of two types; (1) the inverted "L" type aerial or (2) the "T" type aerial.

These types are illustrated in Figs. 11 and 12 respectively, from which also will be gathered the method of connecting the insulators in series and of securing the down-lead, so that mechanical strains set up by high winds are not applied to the actual leading-in wire connected to the instruments.

From the lower end of the down-lead a well-insulated conductor (flexible or otherwise) is to be taken through an insulating tube of glass, pertinax or ebonite, which tube should be fitted through a convenient window-frame or the wall of the instrument room.

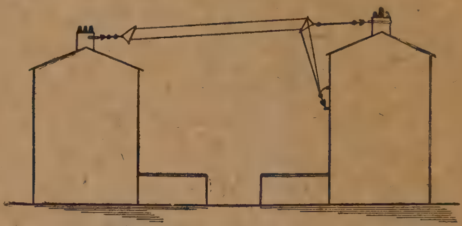


Fig. 13.—Inverted L-type Aerial, Twin-wire

The Twin-wire Aerial.—Should considerations of space prevent the erection of a long single-wire aerial, the next best plan is to erect a twin-wire aerial, as long and as high as possible, with a lead from each wire joined together just outside the instrument room, as shown in Fig. 13. The two wires of the aerial should be spaced upon light but strong spreaders of bamboo, ash or even metal tube at

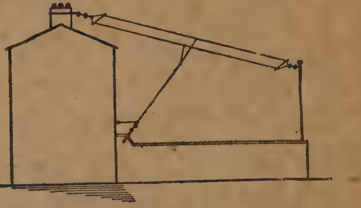


Fig. 14.—T-type Aerial, Twin-wire, for Use When Space is Restricted

least 5 ft. long, the necessary insulation being provided for between the bridle and the chimney or other attachment.

The T-type Aerial.—It may be desirable, in order to make use of, but not to

exceed, the permitted length of wire, to erect a two-wire aerial with down-lead from the centre, in which case in order to avoid having the down-lead, make an acute angle with the aerial proper; an arrangement as in Fig. 14 may be used.

The Earth Connection.—As a rule an earth connection, by means of a stout copper wire (single or stranded) to the nearest water-pipe, will be found most convenient and in general quite satisfactory. If a single wire is employed, it should not be smaller than No. 16 S.W.G., and should be soldered or tightly clipped on to the cleaned water-pipe as near to the latter's point of entrance to the building as possible.

If the aerial is being erected in a more or less open space, however, and away from any water-pipes, several long lengths of bare copper wire—some beneath the aerial and others radiating away from the instrument room—should be laid in small trenches in the ground (say 10 or 12 inches deep) and covered over with soil. Alternatively, a single length of wire netting (not necessarily new) may be merely laid out on the ground beneath the aerial, secured temporarily in place by means of heavy stones, and readily removed when not in use.

Wave-length of Aerial.—An aerial is said to have a "natural" wave-length, and this is determined by the inductance and capacity values distributed over the circuit of which the aerial forms a part. Practically this natural wave-length is determined by the electrical length of the aerial together with the number of wires of which it is composed, and their average distance above the ground. As the electrical length of an aerial is the distance from the earth connection direct to the far end of the aerial wire, it will be seen that, for a given *quantity* of wire, an **L**-type aerial will have a greater natural wave-length than a **T**-type aerial. The necessity for making connection to the *exact* centre of a **T**-type aerial will also be apparent, as otherwise the aerial would be badly balanced electrically, having, in effect, two natural wave-lengths slightly different from one another.

It is impossible to lay down hard and fast rules regarding the erection of aerials for amateur experimental purposes as conditions vary, but a few trials carried out along the lines indicated in the foregoing will quickly show which arrangement gives the best results in any particular circumstance. Great care should be taken over the insulation of a small aerial in particular, as the total amount of energy picked up does not leave much margin for leakage. All joints and connections should be carefully soldered, making use of some non-acid flux in order to avoid subsequent corrosion and weakening of the wires.

MAKING A LONG-DISTANCE CRYSTAL RECEIVING APPARATUS

There will now be described a compact, long-distance receiving apparatus of proved efficiency; full details of construction and specification of quantities will be given to enable any reader to make for himself a similar apparatus. The set embodies several features believed to be original, and is specially adapted for ease and quickness in manipulation (the former in particular being of great value to inexperienced amateurs). Fig. 15 shows the complete apparatus, with the front and top of the box removed, and it will be seen that the outfit is quite compact and portable.

General Description.—The set includes an inductively coupled tuner—that is, a tuning coil in which two separate windings are used. The primary winding, which is in the aerial circuit, acts inductively on the secondary winding, to which is connected the detector circuit. The windings are tapped off to contact studs, and these, together with their respective switches for both primary and secondary coils, are at one end of the tuner. The coils are totally enclosed, and therefore are not liable to be damaged by any careless handling.

Referring to Fig. 15, the contact studs of the primary coil will be seen with the aerial tuning switch in a vertical position half-way round, and below are the contact studs (thirteen in number) of the secondary

with, in this case, two tuning switches, the reason for which is as follows: If the primary tuning switch is in the position shown, the current from the aerial enters the primary coil at a point approximately half-way along, traversing all the turns of wire between that point and the far end or back of the coil, where it passes away to earth. The number of turns included in circuit can be increased or decreased by moving the switch to the right or left. The number of turns of the secondary coil included in circuit can, of course, be varied in a similar manner; but, in addition, the position of the required number of secondary turns in relation to

Fig. 15.—Long-distance Receiving Apparatus (Crystal) with Front and Top of Box Removed

the active primary turns, or what is technically known as the "coupling," can also be varied by operating both of the switches at once in the same direction. For instance, referring again to Fig. 15, when the secondary switches are in the position shown, the whole of the secondary coil is in circuit. If the upper secondary switch is moved down to the centre stud, half of the turns will be in circuit from the middle of the coil to the far end. The coupling is then said to be "tight." But if the lower secondary switch is moved six studs to the left (the upper switch being replaced at the left-hand end stud), the secondary turns in circuit will be those from the front of the coil to the middle, right away from the active turns of the primary. The coupling is now said to be "loose."

It will, of course, be seen that many intermediate degrees of coupling are possible, and, further, the adjustments can be made quietly and quickly, while listening to signals, until the best position is found.

In the bottom left-hand corner is fitted a small tubular condenser (the inner tube being shown projecting about half its length), the purpose of which is to make a close adjustment between any two studs of the primary circuit and so obtain more exact tuning.

Of the terminals on the front of the instrument little need be said at present, except that the top right-hand terminal is for the aerial lead, the top left-hand one is for the earth connection, whilst the two in the bottom right-hand corner are for the telephones.

On the top to the left is a variable condenser for adding capacity to the secondary circuit. This condenser, it will be noticed, has the movable veins arranged to slide horizontally in between the fixed vanes, the dielectric being glass, and will be found to be much more easily constructed than the circular half-plate type, the vanes of which revolve.

The blocking condenser is not visible, being fixed to the under-side of the coil cover just below the variable condenser. The telephones are connected across the blocking condenser. On the right of the variable condenser is the detector, made to such dimensions as would allow a small glass tumbler to be utilised as a cover. The crystals are zincite and bornite.

The remaining space on top of the coil is used to stow the telephones when not in use, and there is room enough to fit a battery and potentiometer if desired, though the author has not yet found these necessary with the crystals specified.

Capabilities of the Apparatus.—As to the capabilities of the set, the following will give an idea of what can be accomplished.

The position of the writer's residence would not allow of either a long or a high

aerial, the one originally used consisting of six wires (No. 16 W.G. hard-drawn copper) suspended between two spreaders each 3 ft. 6 in. long, the latter being fixed to window frames at a height of about 20 ft. only above ground level. The total distance between spreaders was 66 ft., and the lead-in was taken from the nearer end, through the window frame, into the instrument room. The earth connection was by means of a bare copper wire (also of No. 16 W.G.) soldered on to the water-pipe at a point close to the kitchen tap. (For present regulations regarding aerials, see an earlier page.)

With the above-described aerial, good signals were received from Seaforth, Paris, Poldhu, Cleethorpes, and Clifden, and from ships off the west coast. The above were all fairly loud, with the exception of Clifden, which, though not loud, was nevertheless quite distinct and readable.

Using another aerial 100 ft. long, of four wires attached to 5-ft. spreaders, one end being about 45 ft. and the other about 35 ft. high, and situated among trees, very loud signals were received from all the above-mentioned stations and from ships right out in the Atlantic. Clifden was perfectly clear and loud, and was heard working almost continuously from about 8 p.m. until 3 o'clock the following morning.

Specification.—A full specification of all the necessary material will now be given.

Specification of Materials

Tuner

2 wood discs, each 4 in. diameter by $\frac{5}{8}$ in. thick.
2 wood discs, each $5\frac{3}{4}$ in. diameter by $\frac{5}{8}$ in. thick.
2 pieces teak, each $7\frac{1}{2}$ in. by $7\frac{1}{2}$ in. by $\frac{5}{8}$ in. thick. One of these may be substituted by a piece of $\frac{1}{4}$-in. or $\frac{3}{8}$-in. ebonite, if desired.
1 piece teak, 12 in. by $7\frac{1}{2}$ in. by $\frac{5}{8}$ in. thick.
1 sheet presspahn, ·8 mm. thick, or cardboard tube of correct dimensions.
4 doz. round-head brass wood screws, $\frac{1}{2}$ in. long.
4 doz. small brass washers (to fit above).
1 doz. countersunk-head iron screws, $1\frac{1}{4}$ in. long.
4 only countersunk-head iron screws, $\frac{3}{4}$ in. long.
1 ft. of springy strip brass, $\frac{1}{2}$ in. wide
3 cheese-head metal-thread screws, $1\frac{1}{4}$ in. long by about $\frac{1}{8}$ in. diameter, with 4 washers and 3 nuts on each.
8 oz. No. 28 W.G. d.c.c. copper wire.
3 oz. No. 36 W.G. d.c.c. copper wire.
1 box of small tacks, about $\frac{3}{8}$ in. long.
Shellac varnish (say about a gill).

Tubular Condenser

1 piece of thin brass tube, 13 in. long, $\frac{3}{4}$ in. inside diameter.
1 piece thin brass tube, 7 in. long by $\frac{5}{8}$ in. outside diameter.
2 or 3 yd. of "sticky" insulating tape.
3 round-head brass wood screws, $\frac{1}{2}$ in. long.
1 wooden knob or handle and $\frac{7}{8}$ in. diameter brass washer.
1 piece of insulated flexible wire 2 ft. long.

Blocking Condenser

1 square 6 in. by 6 in. of $\frac{1}{4}$-in. teak (to make base and top).
1 sq. ft. of thin sheet zinc.
2 small terminals (screw-in type).
Presspahn (already specified).
4 round-head brass wood screws, $\frac{1}{2}$ in. long.

Variable Condenser

1 sq. ft. $\frac{1}{4}$-in. teak (to make box).
1 sq. ft. thin sheet zinc.
2 small brass nuts and bolts, $\frac{3}{4}$ in. long by $\frac{1}{8}$ in. diameter.
1 knob (off rubber stamp or screwdriver).
2 small brass terminals (screw-in type).
8 in. of electric light flexible wire.
6 old quarter-plate negatives.

Detector

Zincite and bornite crystals.
1 4-in. square pattress or switch base.
1 piece of rod ebonite, $\frac{3}{4}$ in. diameter by $1\frac{1}{4}$ in long (brass rod, or even tube will do).
2 small brass cartridge cases (one $\frac{1}{4}$ in. and one $\frac{3}{8}$ in.).
1 piece springy strip brass, $\frac{1}{2}$ in. wide by, say, 4 in. long.
1 piece hard strip brass about $\frac{1}{8}$ in. thick by $1\frac{1}{2}$ in. long.
1 metal-thread, countersunk-head brass screw, $1\frac{1}{4}$ in. long by $\frac{1}{8}$ in. diameter.
2 metal-thread round-head brass screws, 2 in. long by $\frac{1}{8}$ in. diameter, with 2 washers and 2 nuts.
2 small terminals (screw-in type).
1 terminal fitting out of electric light ceiling rose, or similar fitting (*see* construction).
1 small glass cover (small tumbler will do).

Sundries

About 6 yd. No. 20 or No. 22 d.c.c. copper wire for various connections.
2 large terminals (bolt-through type) for aerial and earth leads.
2 smaller ditto for telephone connections.

Originally designed with a view to low cost, the set as described, employing materials as specified, gave excellent

results, and has for some years given satisfaction to great numbers of amateur experimenters, especially beginners who had no previous experience in matters wireless.

As wireless materials are now readily obtainable, however, certain modifications may be made if desired with a view to obtaining a more efficient and workmanlike set.

Such modifications refer to the materials to be used rather than the dimensions or arrangement of apparatus, and comprise : (1) The use of an ebonite panel carrying all contact studs, terminals and tuning switches, in lieu of the teak originally specified. This will, of course, necessitate the use of metal thread screws, say No. 4 or No. 5 B.A., for the contact studs. (2) As strong cardboard tubes up to 6 in. in diameter are now readily obtainable, there is no necessity to make the formers on which the inductances are wound of presspahn as in the original set. (3) If desired, the "rotary vane" type of variable condenser, having a maximum capacity of approximately ·0003 mfd., may be substituted for the sliding-plate type of condenser described. (4) A potentiometer may be fitted and connected in the detector circuit (between the crystal detector and telephone receivers) to enable other crystal combinations requiring an initial potential to be applied to the point of contact, to be tried if desired. Such other combinations are (*a*) tellurium-zincite ; (*b*) zincite-chalcopyrites ; (*c*) carborundum-steel. (5) If desired, a three-electrode thermionic valve may be employed as a detector and will permit the reception of continuous-wave signals. Later in this chapter is described a complete and compact valve panel which may readily be used in conjunction with the receiving set about to be dealt with, the valve panel either forming a separate unit apart from the receiving set or, being mounted above the tuning coils, forming part of the set, a point the individual will decide.

The Tuner.—With regard to the actual details of construction, the largest item, namely, the tuner, will first be dealt with. Take the two 4-in. wood discs, and in the centre of each bore a hole, $\frac{3}{4}$ in. in diameter in one and $\frac{1}{8}$ in. in diameter in the other. Then, having cut off from the sheet of presspahn a piece measuring 9 in. by 1 ft. $1\frac{1}{2}$ in., tack it to the edges of the two discs, forming a cylinder a little over 4 in. in diameter by 9 in. long. This will leave a lap of about $\frac{3}{4}$ in. Tack it at the ends, join or fasten down along the cylinder with glue, and give the whole a coat of shellac varnish. Obtain a piece of tubing about $\frac{5}{8}$ in. in diameter by 2 ft. long, and having plugged one end with wood, pass the plugged end through the $\frac{3}{4}$-in. hole in the end of the cylinder. Insert a wood screw through the $\frac{1}{8}$-in. hole in the opposite end, and screw it into the wooden plug sufficient to hold and yet allow the cylinder to revolve easily upon the tube. An ordinary thread reel attached loosely to the latter disc will serve as a handle, and if the projecting piece of the tube is now gripped in a vice or clamped to a table or bench, the cylinder is ready for the wire to be wound on (see Fig. 16).

Mark off the clear space lengthwise between the tacks into twelve equal parts, as shown. Now take the No. 36 W.G. d.c.c. wire, secure it by means of a small brass screw to one of the discs, leaving a loose end of the wire about 1 ft. 6 in. long, and wind it evenly round the cylinder, beginning just clear of the tacks. As the wire reaches each of the eleven marks, make a loop of about 1 ft. 3 in. of wire (measured double), giving it a twist close to the cylinder to secure it. Allow about 1 ft. 6 in. of loose wire at the termination of the winding, and secure to the disc as before. The wire must all be wound close (that is, touching), and as smoothly and evenly as possible.

There are several different methods of making the tappings from the inductance coil. The method just described is very simple, but has the disadvantage that the double wires of each tapping have to be traversed by oscillatory currents in the inductance. By a better method, at each tapping-point the wire is bent back on itself (say for $\frac{1}{2}$ in.), and the small loop thus formed is taken between the finger and

thumb and twisted round two or three times, the winding being then continued, leaving the loop standing. Each loop is afterwards cut at the outer end, the two ends of wire carefully cleaned and twisted

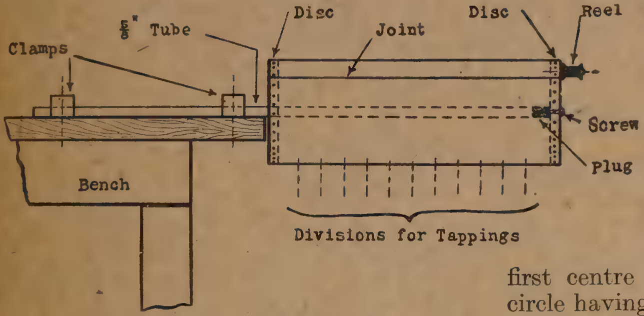


Fig. 16.—Secondary Cylinder Mounted on Spindle Ready for Winding

together along with the bared end of a length of insulated connecting wire, and the whole is soldered.

Alternatively the insulation may be removed from the wire as each tapping-point is reached, then when once the loop is formed and twisted up tight, it need not be further disturbed except to solder to it the end of the insulated connecting wire.

Before handling the coil any more than necessary, it should be given a good coat

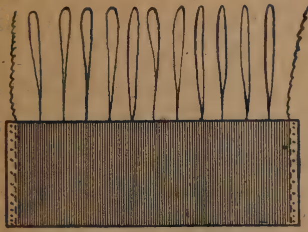


Fig. 17.—Secondary Coil after Winding, Showing "Tappings"

of shellac varnish, two coats if the varnish is at all thin. This completes the secondary winding of the tuner, which should now resemble Fig. 17.

One of the $7\frac{1}{2}$-in. by $7\frac{1}{2}$-in. pieces of teak has now to be marked off for the contact studs and switches, care being taken to see that the wood is thoroughly dry.

Place the point of a pair of compasses in the exact centre of the square, and describe two dotted circles, one $4\frac{1}{8}$ in. in diameter and the other $5\frac{7}{8}$ in. in diameter, to indicate the positions to be occupied by the secondary and primary coils respectively when fixed in position. Then mark off three new centres, *a*, *b*, and *c* (Fig. 18), the first being $\frac{3}{8}$ in. above the original centre (that is, the centre of the square), the second $\frac{3}{8}$ in. below it, and the third $\frac{3}{4}$ in. below the second. About the first centre (*a*) describe two-thirds of a circle having a radius of $2\frac{7}{8}$ in., and about the second centre (*b*) a half-circle having a radius of $2\frac{1}{4}$ in. Mark off on the former either twenty-nine or thirty equal divisions and on the latter thirteen. These are the centres for the contact studs, and the distance they are apart depends on the size of the washers and screw-heads forming the studs.

Drill a hole $\frac{1}{8}$ in. in diameter through

Fig. 18.—Contact Studs, Terminals, etc., on Front End of Tuner

the centres *a*, *b* and *c*, also holes of the same diameter for the screws, securing the coils to the square ends in the positions shown at S (Fig. 18), and for the four terminals, with one $\frac{3}{4}$-in. hole for the tubular condenser.

All the brass contact screws may now be fixed in position, with one small washer

under the head of each. Do not screw them up tight, but leave room to slip the wires from the coils under, between the head of the screw and the washer. As close as possible to each of the upper or primary contacts, but in such a position as to be accessible from the back after the coils are fixed in place, drill a small hole (say $\frac{1}{16}$ in. in diameter), through which to pass the wires when connecting up (see Fig. 18).

Similar small holes are also required for the lower or secondary studs; but in this instance they may all be drilled close to the screw-heads on the lower side, and having temporarily fixed one of the $5\frac{3}{4}$-in. wood discs to the back by means of wood screws through the holes S (taking care to keep it central), drill them through the

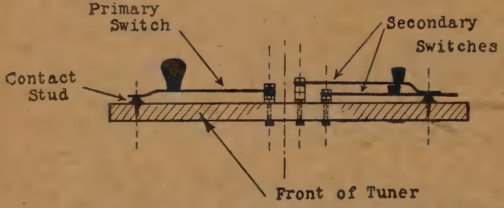


Fig. 19.—Sectional View of Front End of Tuner, Showing Switches and Method of Securing Them

disc as well. Mark on the disc the three points where the screws of the tuning switches will come through, and either drill or gouge out a recess to allow the head of each screw to enter. Mark the disc and square end-board to ensure their being fitted together again correctly, and take them apart.

If it has been decided to substitute an ebonite panel for the teak end-piece originally specified, it will be necessary to fit contact-studs having metal-thread screws (probably No. 4 or No. 5 B.A.), and holes for these should be carefully drilled and tapped in the ebonite. The application of a little thick shellac varnish to the screws before inserting will ensure that the contacts remain tightly in place and will dispense with nuts. Whether nuts are fitted or not, it is advised that all connections to the contact studs should be soldered to the screw-point (behind the panel), and for this purpose the diameters of the primary former or tube and of the pitch circle of primary contact studs should be proportioned so that the screw points project clear behind the ebonite panel to facilitate connecting up.

Cut off from the length of springy brass strip three pieces to make the tuning switches. Shape them and fit small knobs or handles. Drill a hole in the end of each, equal to the diameter of the metal-thread screws, and having passed the latter through the end-board from the back, with a washer and the bared end of, say, a 1 ft. 6 in. length of insulated wire under the head of each, and secured them firmly with nuts, mount each switch between washers on its respective screw. Fig. 19 shows the shapes to which the switches must be bent, also the method of securing same.

Fit four small screws to act as stops, as shown at W (Fig. 18). The disc through which the small holes have just been drilled must now have a $\frac{3}{4}$-in. hole drilled through the centre, and be screwed to that end of the secondary coil in which there is also a $\frac{3}{4}$-in. hole, the loops of wire from one end to the other of the coil being threaded consecutively through the small holes, noting carefully which is the wire from the far end of the coil (see Fig. 20). These wires may now be bunched together and tied with a piece of tape to keep them out of the way.

Screw the remaining $5\frac{3}{4}$-in. disc to the opposite end of the secondary coil (having first drilled a $\frac{1}{8}$-in. hole in the centre of it for the screw on which it has to revolve when being wound); cut a piece of presspahn of the required size (about $10\frac{1}{4}$ in. by 1 ft. 7 in.), and tack it to the discs (gluing down the lap as before), making a cylinder $10\frac{1}{4}$ in. long by a little over $5\frac{3}{4}$ in. in diameter. After giving it a coat of shellac, mount it on the piece of tube as before, attach the thread reel, and it is ready for the primary winding.

Take the No. 28 W.G. d.c.c. wire, secure it to one disc, leaving about 1 ft. 6 in. loose, and proceed to wind in the same direction as the secondary, tapping off as follows:

Wind ten turns, then make a loop (or "tap," as it is called), another ten turns and tap, then a further ten and tap; now divide the remaining space into a number of equal parts, so that the total number of tappings, including the two ends, exceeds the total number of primary studs by one. This is because the end of the wire at the far end of the coil is connected direct to the "earth" terminal on the front of the instrument. Wind the coil, tapping as already directed, and leaving about 1 ft. 6 in. of the wire loose at the termination, and give the whole a good coat of shellac.

When the varnish is quite dry, bend all the loops of wire towards the far end, away from the projecting secondary wires, and secure them there out of the way. Stand the coils up on end, with the secondary wires at the top, and holding the square end, with the studs and switches on, in one hand above it, thread each of the secondary wires through one of the thirteen small holes corresponding to the hole in the disc through which the wire projects. When all are through, gradually approach the square end to the disc, drawing the wires taut from time to time, until the square end rests on the disc. As the holes in both the disc and the square end were drilled together, the wires should run straight through without much trouble. See that the disc is in its correct position (as previously marked), and secure with the three screws as before.

Here again some slight variation in method of assembly will be required if an ebonite front panel is being fitted, and it will probably be found advantageous to cut a clear slot equal to about a quarter of the circumference in the wooden disc instead of separate small holes.

A spare length of wire sufficient to permit of soldering to the contact screws should be allowed, and when the connections are completed this surplus may be stowed inside the coil.

Now carefully remove the insulation from each wire close to the contact screws, and pass each under the head of its allotted screw (between the screw-head and the washer), and gently screw up tight. The greatest care must be exercised in removing the insulation and the connecting up of this fine wire, as same is easily broken, and should a breakage occur at this stage a great deal of trouble would be caused.

The primary wires may now be treated in a similar manner, this time, however, beginning with the first loop and not with the single wire at the far end.

The diagram (Fig. 20) shows all the connections from the primary and secondary coils to the contact studs, and reference to it will clear up any points in the foregoing description which may not be quite understood.

The two large terminals may now be fixed in position, as shown at A and E (Fig. 18), the wire from the aerial tuning

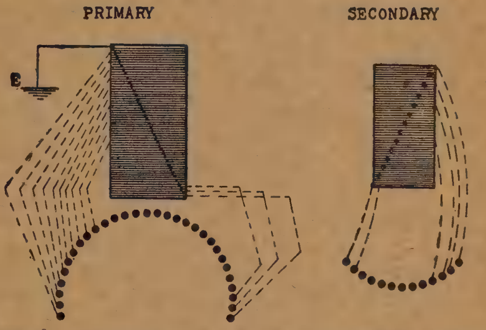


Fig. 20.—Diagrams of Connections from Coils to Contact Studs

switch being connected to terminal at A and the loose end of the wire from the far end of the primary winding being connected to that at E.

The remaining $7\frac{1}{2}$-in. square of teak may now be attached to the disc at the far end of the coils by means of three wood screws, the cover screwed on, and the tuner is complete.

The Tubular Condenser.—The next item to be constructed is the tubular condenser, and it will be found to be a very simple job compared with the previous one.

Take the piece of $\frac{3}{4}$-in. inside diameter brass tube, make saw-cuts in the ends, and bend to form lugs for securing the tube to the ends of the tuner, removing the portions not required. The overall length, when finished, should just allow of its being inserted between the coil ends.

Cut away half of the tube on the inner side at the far end for about 3 in. long, to allow the flexible conductor from the inside tube to move in and out, and fix in position exactly opposite and in line

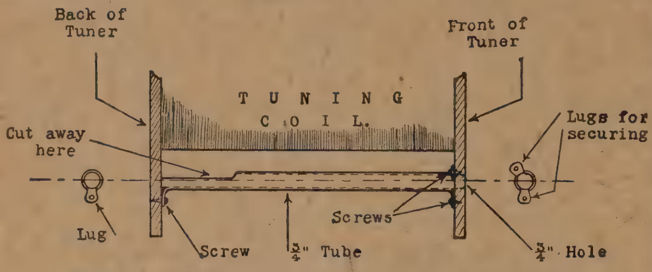


Fig. 21.—Tubular Condenser and Method of Fixing

with the ¾-in. hole in the front of the tuner. Fig 21 shows what is required, and Fig. 22 shows the condenser in position between the ends of the tuner.

The piece of ⅝-in. outside diameter tube must now have a small hole (say $\frac{1}{16}$ in.) drilled through it about ¼ in. from one end, and a groove filed round it in line with same. The bared end of the flexible wire is then passed through the hole from the inside, wound once round the tube in the groove, passed through the hole again in an opposite direction, and soldered to the tube. Plug the opposite end of this tube, and, having attached a handle or knob of some description with which to move it about, wrap it carefully from end to end with the sticky tape, and coat it with shellac. Insert the flexible cord through the ¾-in. hole in the front of the tuner, followed by the brass tube. The inner tube must slide easily in the outer one, and should be provided with a brass washer, fixed under the handle, of such a size that it cannot enter the ¾-in. hole.

The capacity of this condenser is varied, of course, by sliding the smaller tube in or out of the larger, and it is connected in parallel with the primary coil by connecting the outer tube, by means of a short piece of insulated wire, to terminal at E (Fig. 18), and the inner tube, by means of the flexible cord, to the terminal at A.

The Blocking Condenser.—The small blocking condenser is made of seven pieces of thin sheet zinc, 2 in. long by 1½ in. wide, each piece being left with a projecting "tab" about ¾ in. long, interleaved with pieces of presspahn or paraffin-waxed blotting paper. Four zinc sheets are connected to one terminal and three to the other.

When the pieces of zinc are cut to shape (see A, Fig. 23), each should have a ⅛-in. hole drilled through the tab, and be levelled by pressing under a hot iron. All the details of construction can be seen from the diagrams A, B, and C (Fig. 23).

For a neater construction of the blocking or telephone condenser (see A, B and C of Fig. 24), obtain four pieces of mica of good quality, each 1 in. square by about ·005 in. thick; two pieces of mica 1 in. square but ·01 to ·02 in. thick; four pieces of tinfoil each 1 in. long by ⅝ in. wide; two pieces of soft brass or copper strip each 1 in. by ½ in. and about $\frac{1}{32}$ in. thick. To one side of each of the four thin pieces

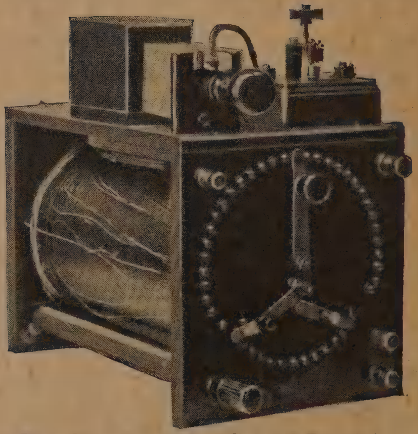


Fig. 22.—Complete Crystal Receiving Apparatus, with Case Removed

of mica a piece of tinfoil is to be shellac-varnished, leaving ¼ in. of foil projecting at one end. These are next to be built up one above another, observing particu-

larly that adjacent foils are separated by mica and that foils 1 and 3 project at one end, and foils 2 and 4 at the other. The two thicker pieces of mica are to be varnished on one side and placed one above

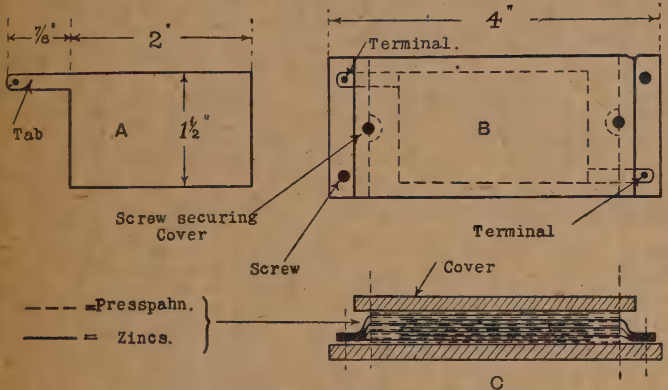


Fig. 23.—Details of Blocking Condenser

and the other below the condenser to strengthen it mechanically, and whilst the shellac is still tacky the whole is to be laid upon a flat surface and pressed beneath a warm (not hot) flat iron or similar metal weight. The two pieces of soft brass are then to be cut as shown at B in Fig. 24, and bent to shape, with projecting lugs for securing the complete condenser in place. When the shellac-varnish is properly set, the projecting foils

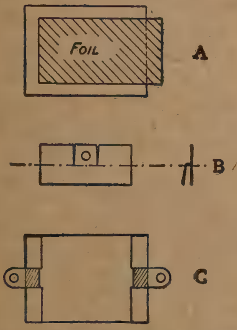


Fig. 24.—Details of Mica-and-foil Blocking Condenser

at opposite ends are to be folded over, the brass clips being placed in position so as to make certain contact with respective foils and squeezed flat in a small vice or with a pair of flat-nosed pliers.

The blocking condenser is fixed to the under-side of the coil cover, directly over the tubular condenser, with two ½-in. screws. It is shown in position in Fig. 22.

The Variable Condenser. — The variable condenser has next to be constructed. Cut out from a sheet of zinc nine pieces to the shape shown by Fig. 25. Trim all ragged edges, slightly round the corners, and make smooth and level by pressing well under a hot iron. Obtain five or six old photographic negatives, and, having removed the films by steeping in warm water, have each cut across into two pieces $3\frac{1}{4}$ in. by $2\frac{1}{8}$ in.

Next make a case or box of the ¼-in. teak, just long and high enough to take the glasses, with a rather wide and projecting base to which terminals may be fixed, and by which the condenser may be screwed to the top of the tuner. As the width of this box will depend on the thickness of the glasses and the zinc sheets, it is necessary to leave the top and one side loose until these are all fitted together.

Each end of this box has vertical saw-

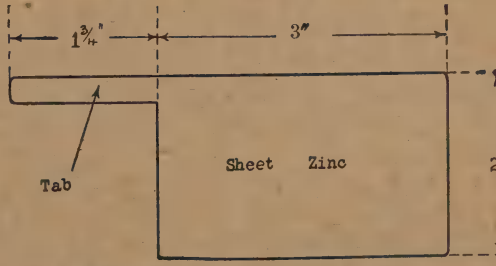


Fig. 25.—Zinc for Variable Condenser

cuts at the top, in which the tabs of the zinc sheets should be a tight fit, the spacing of the cuts being done from the tabs them-

selves whilst held with the glass plates, and the opposite zinc sheets interleaved between them. There will, of course, be five saw-cuts in one end (the fixed end) and only four in the other. Small bolts and nuts serve to connect the tabs of each set of plates firmly together, but it must be noted that the holes for same should not be drilled until the tabs have been bent into shape and squeezed with pliers. To the movable end of the box (with the four plates attached) screw a knob or handle to move the plates in and out. An old rubber stamp handle will do splendidly.

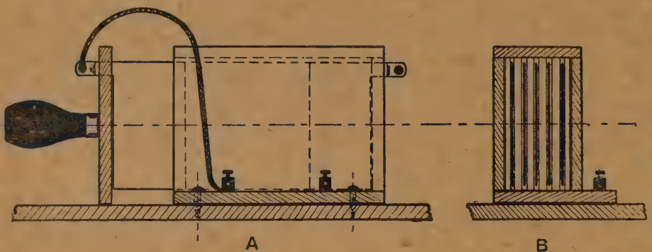


Fig. 26.—Variable Condenser

When assembling the condenser, give each piece of glass a good daubing with shellac on that side which is in contact with a fixed plate only, and place in position wet. This will prevent the glass plates being withdrawn along with the sliding zincs, though such an occurrence is not fatal.

The tabs of the movable zincs are connected by means of a short piece of flexible cord to one of the terminals on the base, the connection from the tabs of the fixed plates to the other terminal being a piece of ordinary insulated wire.

The diagrams A and B (Fig. 26), in conjunction with the foregoing description, will, it is hoped, convey all the necessary information.

When completed, the variable condenser should be screwed to the cover of the tuner, as shown in Figs. 15 and 22, taking care to set it back from the front edge, so that when the movable plates are withdrawn the wooden end carrying them is properly supported.

A small screw inserted close to the edge of the top of the tuner will act as a stop, and prevent the plates being withdrawn altogether.

As already mentioned, a variable condenser of the rotary-vane type may be substituted for the condenser just described if desired; there are many excellent condensers now on the market at reasonable prices.

The Crystal Detector.—Only one more piece of apparatus is now required to complete the set, namely, the detector. It will be found to be a great advantage to have this under a cover of some sort, in order to protect the crystals from dust.

Fig. 27 shows the construction of the detector, the crystals being zincite and bornite. The pillar is made of a piece of ebonite $1\frac{1}{4}$ in. long by $\frac{3}{4}$ in. in diameter. A hole $\frac{1}{8}$ in. in diameter is drilled through the centre, and then a piece $\frac{1}{4}$ in. long is sawn off one end. The arm which carries the upper crystal (the zincite) is made from a piece of the springy brass $\frac{1}{2}$ in. wide, one end being drilled and shaped to correspond with the ebonite pillar. The other end has a small socket, with set-screw in the side (out of an old ceiling rose),

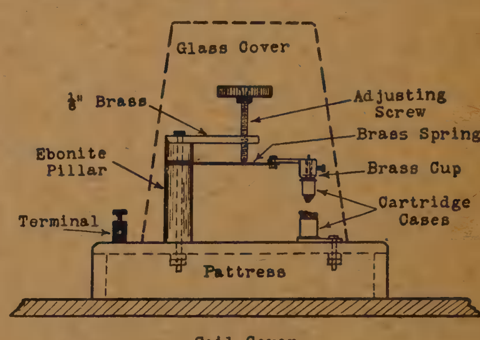


Fig. 27.—Details of Zincite-bornite Detector

attached by means of a small bolt and nut. This must be attached so that it can be moved radially, which permits of the whole surface of the lower crystal being utilised.

The cup into which the upper crystal is fixed is merely a small cartridge case, about ¼ in. in diameter, with a hole drilled through the bottom, and a fine brass screw, ½ in. long, inserted, the head of the screw being inside the case. Then, after the crystal has been fixed in the cup (by melting solder in the cup and pressing the crystal in whilst molten), the point of the screw is passed up through the socket on the brass spring, and the set-screw tightened.

The arm carrying the adjusting screw is a piece of ⅛-in. hard brass, shaped and drilled at one end the same as the brass spring, the other end being slightly tapered and tapped to take the 1¼-in. by ⅛-in. brass adjusting screw. The writer has found that, with zincite and bornite, the thread of the adjusting screw need not be particularly fine, an ordinary ⅛-in. Whitworth thread being suitable. The insulating disc at the top of the adjusting screw should be made of ebonite.

Having made this portion of the detector, fit it up by passing a 2-in. metal-thread screw through the holes in the ⅛-in. brass, the ebonite washer, the brass spring, the pillar, and the top of the pattress (which forms the base) in the order named, and secure with a nut underneath. With this part fitted in place, the position to be occupied by the lower crystal will be quite easily seen.

The cup for the lower crystal is also a small cartridge case (say ⅜ in. in diameter) with the crystal set in solder, and a screw projecting through the bottom. Here the screw has a metal thread, and screws into a tapped hole in the brass base-plate, being filed flush underneath. The base-plate is secured in position on the pattress by means of a ⅛-in. bolt and nuts.

Fix the two terminals to the base, so that they will come outside the glass cover, and connect one to the bolt which passes through the pillar, and the other to the bolt which secures the base-plate, with pieces of insulated wire. Both these connections are, of course, underneath the base and out of sight. Secure the detector to the coil cover (by means of two screws passing through opposite corners of the pattress) in a position where it will be easily accessible.

Connecting up Complete Set.—Now that all the component parts of the set are completed and fitted in position, it only remains to explain how they are to be connected up, and to give a few instructions on working the set. With regard to the former, the diagrams (Fig. 28), with the accompanying description, will show exactly what is required.

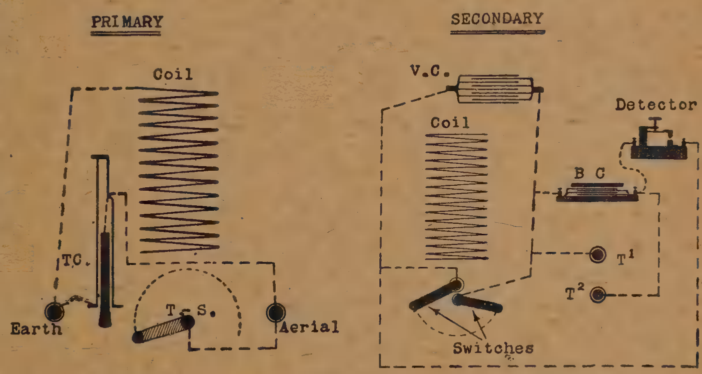


Fig. 28.—Complete Diagram of Connections of Crystal Receiving Apparatus

The connections for the primary were made when the tubular condenser T C was fitted; but the diagram will, perhaps, enable them to be better understood. The secondary circuit is connected up as follows: Connect the lower secondary switch to the upper telephone terminal, also to one side of both the variable and blocking condensers. Connect the lead from the upper secondary switch to the lower crystal of the detector, and to the unoccupied terminal of the variable condenser. Now connect the upper crystal of the detector to the unoccupied terminal on the blocking condenser, from which point lead a wire to the lower telephone terminal.

As previously stated, the construction of the box in which to fit the complete apparatus is left to the individual taste of readers, some of whom may, if the set is not likely to be moved about, decide not to do any more than cover in the open sides of the tuner, and mount it on a plain base.

Now connect the wires from the aerial and earth to their respective terminals, likewise the telephone codes.

With regard to the telephones, it is necessary that these should be good. A single 1,000-ohm headgear receiver was first used in conjunction with the set, and gave quite good results, but a double set (4,000-ohms total resistance), used later, proved very much better, and, in fact, all that could be desired.

If a small induction coil can be obtained (or an electric bell with the gong removed), place it, along with a battery, about 2 ft. away from the receiving apparatus, and, by means of a push-button, work it intermittently whilst gradually screwing the upper crystal of the detector down to the lower one, until a point and a pressure is found which gives a maximum "buzz" in the telephones when the coil or bell is worked.

Working the Set.—Let the first trial take place at night, listening for the stations in the table given on a later page at the times given, and with the various switches, etc., set as described opposite.

Begin with the movable portion of both variable condensers drawn as far out as possible, without removing same.

It will be noticed in this trial that the lower secondary switch has not been moved, nor has any use been made of the variable condensers; but, if Poldhu is being heard (9·30 p.m. G.M.T.), it is a good time to try them.

Reference to the "list of stations" at the end of this chapter will enable the experimenter to "listen-in" for various stations at convenient times and, to facilitate the tuning of the receiving apparatus, the following approximate adjustments of primary and secondary tuning switches will prove useful. In all cases it is to be understood that the secondary condenser is either at minimum or some small value.

Wave-length	*Primary Stud*	*Secondary Studs*
metres		(from left)
600	2	1—2
900	3	1—3
1,200	4 or 5	1—4
2,000	5 or 6	1—5
2,600	9 or 10	1—7
3,500	15 or 16	1—8
4,000	20 or 21	1—10 or 11
5,600	28 to 30	1—13, plus secondary condenser

With the primary switch on the stud where Poldhu is heard at the loudest, slowly push in the tube of the tubular condenser, and note the effect. This is tuning in between the studs. If signals are not improved, move the primary switch one stud lower, and again try the condenser.

Having found the best position for the primary switch, move both secondary switches towards the left, one stud at a time, and note the effect. When the upper secondary switch is at the extreme left-hand side, re-tune the aerial with the primary switch, and add a little capacity to the secondary circuit by means of the variable condenser on the top. The effect of this should be to bring the signals up loud again, the "loose coupling" minimising interference from any other station.

When listening for ships or other stations using wave-lengths of 600 metres, place the primary tuning switch on the first or second stud (left-hand side), and the secondary tuning switches one each on either the first and third studs (right-hand side), or on the eleventh and thirteenth.

As has been stated, the tuner is capable of tuning in Clifden, whose wave-length is 5,600 metres, without any auxiliary inductance or "loading coil," and when listening for this station place the primary tuning switch on the twenty-fifth or twenty-sixth stud with all the secondary

coil in circuit (that is, with the secondary tuning switches at opposite ends of the half-circle of studs), and with probably about half of the secondary variable condenser added.

With these instructions to guide him, the beginner will, it is hoped, succeed in receiving signals without the discouraging nights of fruitless "listening" that have been the lot of many in earlier days, and once signals are received, improvement is comparatively easy.

As mentioned earlier in this chapter, the addition of a three-electrode valve, suitably connected, will permit of continuous-wave signals being received.

This, of course, is not possible with the crystal receiver alone, such a set being suitable for reception of "damped" waves only. At the same time, provided the distance between transmitting and receiving stations is not too great, radio-telephony may readily be received upon a receiving set fitted with merely a crystal detector.

However, in general it will be found preferable to make use of a three-electrode valve, as it is possible by suitably arranging the receiver circuits to secure great sensitivity together with considerable amplification of signal strength.

MAKING A COMPLETE VALVE PANEL

In continuous-wave radio-telegraphy, especially good results have been obtained by the use of the three-electrode valve (or Triode)—the thermionic valve—and it is therefore proposed to describe the construction of a complete valve panel (Figs. 29 and 30), and explain how it is to be used in a receiving set. There are advantages in commencing continuous-wave (c.w.) and "valve" experimental work with a comparatively simple piece of apparatus.

The constructional work is well within the capabilities of the amateur; but few tools are required; the total cost is not high, and the instrument may be used with almost any existing receiving set, from the simplest single- or two-slide tuning-coil outfit to the most elaborate inductively-coupled tuner. Thus the construction of this one piece of apparatus and the purchase of the necessary three-electrode valve, 4-volt or 6-volt accumulator and high-tension (or anode) battery, opens up a wide and extremely interesting field for experimentalists. The type of valve with which this valve panel is intended to be used is the "hard, open-grid" valve.

Specification.—*Panel:* Ebonite sheet 7 in. by 5 in. by $\frac{3}{8}$ in. thick. Knob for rheostat; purchased ready-made or turned from ebonite rod $1\frac{1}{2}$ in. in diameter by 2 in. long, which includes for holding in lathe chuck. *Rheostat:* One disc of fibre, $2\frac{1}{2}$ in. in diameter by $\frac{1}{2}$ in. thick; 3 yd. of No. 21 S.W.G. "Chronic" resistance wire; one brass cheese-head Whitworth screw, $\frac{1}{4}$ in. in diameter by $1\frac{3}{4}$ in. long; one piece of hard brass for contact arm, 2 in. long by $\frac{1}{2}$ in. wide by (say) $\frac{1}{32}$ in. thick; two No. 4 B.A. screws $\frac{3}{4}$ in. long and two No. 4 B.A. screws $\frac{1}{4}$ in. long for securing resistance wire and to act as "stops" for switch; two No. 2 B.A. screws $\frac{3}{4}$ in. long, for securing rheostat to back of ebonite panel. *Valve holder:* Four brass cheese-head Whitworth screws $\frac{1}{4}$ in. in diameter by $\frac{3}{4}$ in. or 1 in. long. *Grid condenser:* Three pieces of mica, each $1\frac{3}{4}$ in. by $1\frac{1}{4}$ in. by ·005 in. thick; two pieces each $1\frac{3}{4}$ in. by $1\frac{1}{4}$ in., but thicker, say ·05 in.; three pieces of tinfoil or copper-foil, each $1\frac{3}{4}$ in. by 1 in. and any convenient thickness, say ·01 in.; two pieces of soft brass (or copper), each $1\frac{1}{4}$ in. by $\frac{5}{8}$ in. and (say) $\frac{1}{64}$ in. thick. *Grid leak:* High resistance leak of "pencil-line" type. *Reservoir condenser:* "Mansbridge" type, in Helsby case, as extensively used with commercial telephone sets. A satisfactory condenser of smaller capacity may be constructed, the materials required being 20 sheets of tinfoil or copper-foil, each $2\frac{1}{2}$ in. by $1\frac{1}{4}$ in.; 21 sheets of mica, each 2 in. by $1\frac{1}{2}$ in. by ·005 in. thick; and 2 pieces of soft brass, each $1\frac{1}{2}$ in. by 1 in. by (say) $\frac{1}{64}$ in. thick, to form end clips and connectors. *H.T. battery switch:* Ready-made, or a simple "knife" switch may be made from two terminals and a small piece of strip brass. *Terminals:* Ten terminals in all, of any

convenient size and pattern. *Containing box:* Any convenient material; 2 in. deep, and the overall sizes, of course, will be the same as the ebonite panels, 7 in. by 5 in. *Connecting wires:* Well - insulated bell wire. The pieces of mica shown (intended to prevent surface leakage over the ebonite) may be omitted if the ebonite is tested with dry-cell and telephone receiver to ensure against surface leakage.

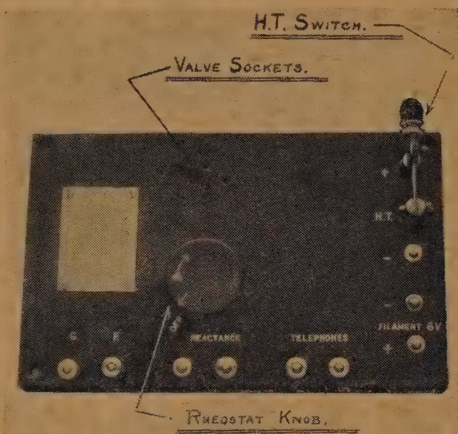


Fig. 29.—Front View of Panel with Valve Removed

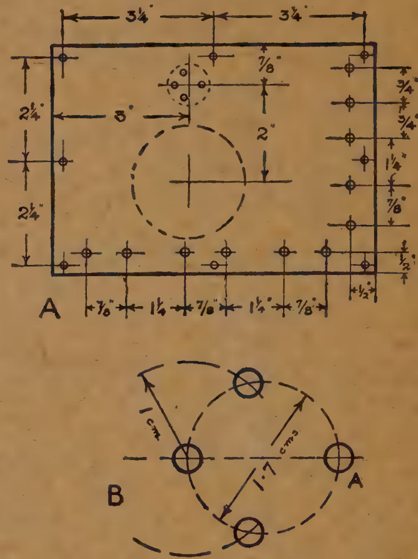


Fig. 31.—(A) Setting-out of Ebonite Panel. (B) Detail of Valve Sockets

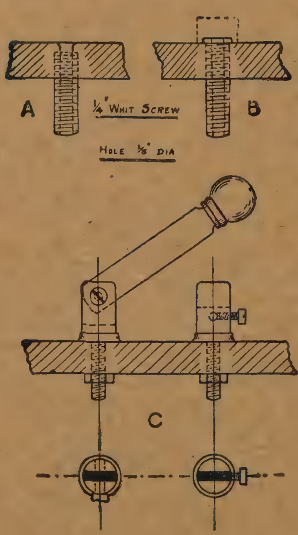


Fig. 32.—Details of Valve-pin Socket and H.T. or Anode Battery Switch

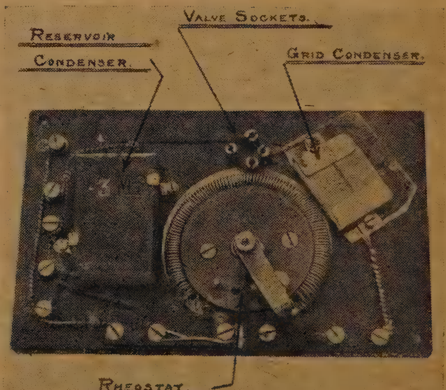


Fig. 30.—Back View of Panel

The Panel.—The ebonite panel is to be squared up on the edges by means of a file and fine glass-paper. It is then to be marked off and drilled as at A and B (Fig. 31). If desired, the holes for the valve-pin sockets may be tapped right through the ebonite from the front and the sockets made to a somewhat different pattern (see detail B, Fig. 32), and screwed home from the front. These sockets are next to be made as at A or B (Fig. 32), and carefully screwed into place, having first had a little thick shellac varnish applied to the threads. All necessary terminals may be fitted in place and screwed up tight. The application of shellac varnish may obviate future trouble due to the terminals working loose.

The H.T. battery switch as at C (Fig. 32) may also be fitted.

At this stage the panel should be placed on one side whilst attention is given to tho condensers and filament rheostat.

Grid Condenser.—To one side of each piece of mica a piece of foil is to be attached by means of shellac varnish, leaving $\frac{1}{4}$ in. of foil projecting at the end, as shown at A (Fig. 33). The three pieces of mica are then to be placed together, observing that the foils are separated by mica and that the two outer foils project at one end and the inner foil at the other. The two

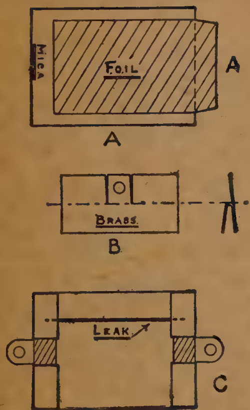


Fig. 33.—Details of Grid Condenser and Leak

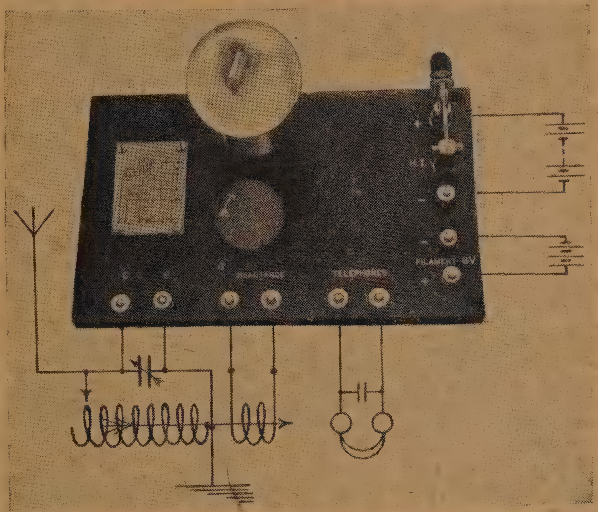


Fig. 36.—Complete Valve-panel with External Connections for Receiving C.W. Signals Shown Diagrammatically

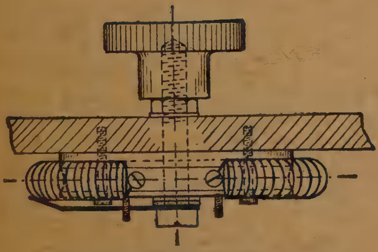


Fig. 34.—Filament Rheostat

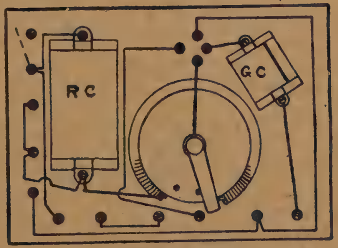


Fig. 35.—Connections at Back of Panel

thicker pieces of mica are to be shellac-varnished on one side and placed one above and the other below the condenser, and whilst the shellac is still " tacky " the whole is to be laid on a flat surface and covered with a warm (but not hot) flat iron. The two pieces of soft brass should be cut and bent as shown at B (Fig. 33), to form clips with connecting and securing lugs.

When the shellac in the condenser is properly set, take a soft graphite pencil and draw a heavy line (say $\frac{1}{16}$ in. broad) from end to end of one of the outer pieces of mica. Fold over the projecting foils at respective ends, so that they make contact on opposite ends of the pencil line, and place the brass clips in position and squeeze up close in a small vice or by means of a pair of flat-nosed pliers.

The completed condenser is shown at C (Fig. 33). The best value of resistance (that is, thickness of pencil line) is subsequently to be determined by actual trial under working conditions, and when correctly adjusted a light coat of shellac varnish will render it permanent. In view of this it is necessary to mount this condenser on the panel with the " leak " outwards and readily accessible.

Filament Rheostat.—First take the resistance wire and wind closely round a wooden former about $\frac{5}{16}$ in. in diameter (for instance, a blacklead pencil). When released, the wire will spring back somewhat, and the coil increase in diameter, probably to about $\frac{7}{16}$ in. The fibre disc should be grooved around the circumference, as shown in Fig. 34, to afford a seating for the coil of wire. The centre hole for the spindle and two holes for securing screws should also be drilled. Two No. 4 B.A. screws $\frac{1}{4}$ in. long are to be screwed into tapped holes in the edge of the disc (in the groove) about 1 in. apart, and one end of the wire having been secured under the head of one screw, the coil is to be carefully stretched round the disc, and the remaining end secured by the second screw. Observe that adjacent turns of the resistance wire do not touch one another.

The disc, with resistance wire attached, may now be fitted and screwed in place on the back of the panel, and the centre hole (for spindle) drilled right through the panel.

Next make the rotating switch arm. Drill it and solder to under side of the head of the spindle ($\frac{1}{4}$-in. Whitworth screw), and mount up as shown in Fig. 34, adjusting the contact arm until it presses firmly but not too heavily on the wire.

Rotate the switch clockwise until the contact arm presses on the end turn of the wire, mark the position, and fix a No. 4 B.A. screw in the face of the fibre disc to act as a stop. This is the " full-on " position. Rotate the switch arm in an anti-clockwise direction until just clear of the resistance wire, which, if found necessary, should be bent down a little to allow of easy movement of the arm. Here place a second stop-screw. This is the " off " position.

The $\frac{1}{4}$-in. brass nut may be soldered to the spindle if desired ; but this should not be necessary, as the ebonite knob, if screwed well up against the nut, will act as a lock-nut. Apply a little shellac to the threads at the end of the spindle before finally screwing up the ebonite knob.

Reservoir Condenser.—This condenser is so called because it acts as a kind of " reservoir " to the anode or H.T. battery, in a manner somewhat analogous to the usual india-rubber gas-bag placed between a gas engine and the gas pipe, in order to maintain a smooth and steady supply. There is no exact capacity required ; the condenser should simply be as large as can conveniently be arranged up to, say, one-quarter micro-farad.

A condenser built up of tinfoil and waxed paper, as used across the interrupter of an induction or spark coil, will be quite suitable, provided the insulation and dielectric strength of the waxed paper will withstand the voltage of the H.T. battery.

The necessary materials as specified being available, the construction of the condenser may be proceeded with on precisely similar lines as in the case of the grid condenser. Similar brass contact-clips will be required, but they must be of larger dimensions.

Both condensers may now be secured in place on the back of the panel by means of No. 4 B.A. screws, and the whole carefully wired up as shown in the diagram of connections (Fig. 35). Care should be

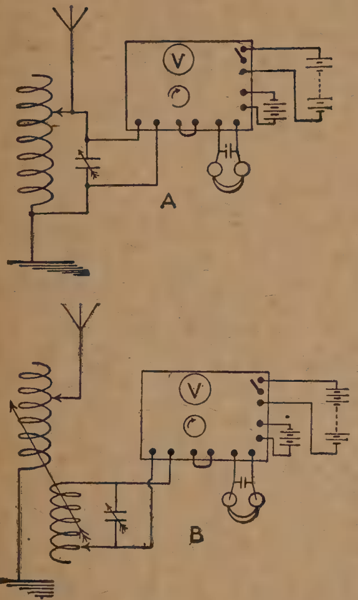


Fig. 37.—Methods of Using Valve Panel for Spark Signals

taken to leave a clear space along all four sides of the panel, corresponding to the thickness of the sides of the containing box.

Containing Box.—This box is simply to form a base for the completed panel, and afford protection for the components and connections on the back of it. It should consist of four sides and bottom only, as the ebonite panel itself forms the top, and should measure over all 7 in. by 5 in. by 2 in. deep.

If it is required to fix the completed panel in a vertical position (for instance, against a wall or board), this may easily be done by removing the ebonite panel and passing suitable screws through the bottom of the box. Small brass mirror-plates may be employed instead, if desired. In view of the simple construction, a view of this box is considered unnecessary.

This completes the construction of the valve panel. Fig. 36 is a photograph of it (minus containing box), showing the valve in place and all ready for putting to work. Note the small diagram of connections mounted on the front of the ebonite panel beneath a piece of transparent celluloid.

Operating the Valve Panel.—With regard to the method of connecting up and using the instrument that has been described, the following points should be carefully noted. The principle of the "three-electrode" valve has already been explained. It should be said that a valve of the "hard, open-grid" type rectifies alternating or oscillatory current applied to the grid-filament circuit, by reason of the grid condenser and leak, and simultaneously magnifies the rectified impulses as explained above. Thus the valve can be made to act as a magnifying detector. This particular application of the valve is shown in circuits A and B (Fig. 37). Neither arrangement, however, is capable of detecting C.W. signals. For this purpose an additional inductance is required, as shown at R in Fig. 38 and known as the "reactance" coil.

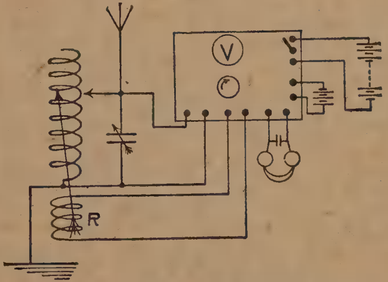


Fig. 38.—Method of Using Valve Panel for Continuous-wave Signals

The actual dimensions of this coil will, of course, be determined by the dimensions of the tuning coil with which it is to be coupled, and the value of inductance is best found by trial; but, in general, the coupling between the coils must be variable and capable of "tight" coupling.

As an example, a suitable reactance coil for use with a tuning coil 6 in. in diameter,

say 10 in. long and wound with No. 28 S.W.G. wire, might consist of 100 to 150 turns of No. 32 S.W.G. d.s.c. copper wire wound in one length without tappings on a $4\frac{1}{2}$-in. or 5-in. diameter former about $2\frac{1}{2}$ in. or 3 in. long, and arranged to slide inside the tuning coil. The purpose of this reactance coil is to pass some of the magnified energy in the anode circuit back into the grid circuit in correct phase, so as to increase the energy in the latter circuit, which is again applied to the grid itself and undergoes further magnification in the valve. This provides a means of greatly increasing the sensitivity of the valve as a detector, and consequently increasing the strength of spark signals, and for the best effect the reactive coupling will be somewhat critical.

If the coupling is increased beyond this point, the transfer of energy from the anode to the grid circuit is such that continuous oscillations are maintained in the circuit, and the valve is said to be "oscillating."

The strength of spark signals under these conditions will be increased enormously, but the true spark note of the transmitting station will not be recognisable. With the receiving valve "oscillating," C.W. signals may be received by means of the interference-beat or heterodyne method (see p. 10 of this chapter), in which the locally generated oscillations are superimposed on the oscillations due to the incoming C.W. signals, and made to give rise to "beats" at an audible frequency. A valve receiver provided with reactance coil, and thus capable of generating the required local oscillations, is known as a "self-heterodyning" receiver.

C.W. signals may be readily and positively identified by the pure musical note, the receiving operator being able to vary the pitch of the note in the telephones by adjusting the inductance or capacity values of the receiving apparatus.

WIRELESS TELEPHONY

The sequence of operations necessary to enable speech, music, etc., to be transmitted from one point to another without the aid of connecting wires are as follows:

(1) Sound waves in air produced by the speech, etc.

(2) Electric current varied by the sound waves.

(3) Electro-magnetic (or "wireless") waves controlled by the sound waves and radiated by a special form of wireless transmitter.

(4) A wireless receiving apparatus, tuned to the same wave-length as the distant transmitter.

(5) Detecting device and telephone receivers.

(6) Movements of telephone diaphragms caused by the received variations of current, resulting in the reproduction of the speech, etc.

In common with the commercial line telephone systems in everyday use, the microphone plays an important part in radio-telephony, but whereas in the former case the varying electric currents caused by the changing electrical resistance of the carbon granules under the action of impinging sound-waves are conducted by wires to the distant telephone receiver, in the latter case the microphone currents must be applied to, and in some way control, oscillatory high-frequency currents which cause the radiation of energy in the form of electro-magnetic waves from the aerial system of a wireless transmitting station, so that not the waves themselves but the microphonic variations only are detected and become apparent in the telephone receivers of the receiving station.

The Transmitting Station.—At the time of writing, methods of attaining the desired object require that a wireless transmitter capable of radiating electro-magnetic waves of constant wave-length and amplitude be employed at the sending station, and that either the wave-length or amplitude (or both) of the emitted waves be varied at audible frequency by the current changes through a suitably connected microphone.

The principal difficulties at the transmitting station consist in: (1) Satisfactorily maintaining the radiation of appreciable energy in waves of unchanging length and amplitude. (2) Efficiently

LIST OF SOME OF THE CHIEF WIRELESS STATIONS

Call-letters	*Station*	*Wave-length (metres) and System*		*Usual times of working*
GCC	Cullercoats			
GCS	Caister			
GLV	Seaforth (Liverpool)			
GKG	Heysham Harbour			
GKR	Wick			
GLD	Land's End	600	Spark	Coast stations working to shipping at all hours of day and night.
GMH	Malin Head			
GNF	North Foreland			
GNI	Niton (Isle of Wight)			
GNV	Newhaven			
GRL	Fishguard			
KAV	Norddeich	600	Spark	10.15 a.m. 9.0 p.m.
KAW	Swinemunde	1,000	Spark	Irregular.
FFB	Boulogne			
FFH	Havre			
FFI	Dieppe	600	Spark	French stations working to shipping.
FFS	Marseilles			
FFU	Ushant			
GFA	Air Ministry	900	C.W.	
		1,300	C.W.	Various.
		1,700	C.W.	
GKU	Devizes	2,100	C.W.	Various.
EAC	Cadiz	2,500	Spark	Midnight.
EGC	Madrid	1,600	Spark	Various.
FL	Eiffel Tower	2,000	Spark	10.44 a.m. 10.44 p.m. Time.
				2.45 p.m. 11.30 a.m. Weather.
		3,000	C.W.	Various.
IQZ	Pola	3,200	Spark	8.30 p.m.
BWW	Gibraltar	2,700	Spark	2.0 p.m. 7.0 p.m.
PRG	Prague	4,100	C.W.	Various.
		4,500	C.W.	8.30 p.m.
OHD	Vienna	5,600	C.W.	Various.
BUC	Bucharest	7,000	C.W.	Various.
BYD	Aberdeen	3,200	C.W.	7.30 p.m.
POZ	Nauen	4,500	C.W.	7.30 p.m.
		3,900	Spark	11.55 a.m. and 11.55 p.m.
GBL	Leafield	9,000	C.W.	8.0 p.m. (Press).
ICI	Coltano	4,000	C.W.	Various.
WAR	Warsaw	2,000	Spark	8.30 p.m.
MPD	Poldhu	2,800	Spark	9.30 p.m.
				1. 0 a.m. (Press).
BYZ	Malta	4,000	C.W.	9.0 p.m.
HB	Budapest	3,100	Spark	9.30 p.m.
MSK	Moscow	5,000	Spark	10.0 p.m.
PCH	Scheveningen	600	Spark	Various.
		1,900	Spark	

varying or modulating this radiation at speech-frequencies.

Any type of continuous-wave transmitter may be adapted to fulfil the required conditions, but for small or moderate power "C.W. valve sets" are being used in increasing numbers.

The microphone may be connected to the wireless set in a variety of ways, such as: (1) Directly in the earth lead. (2) In the grid-filament circuit of the oscillating valve, usually via a step-up iron-core transformer. (3) To a special control valve which in turn is connected either to the grid or main supply circuit of the oscillating or power valve.

A further practical difficulty lies in the present necessity for switching over from transmitting to receiving, and this point offers considerable scope for experimental work.

The Receiving Station.—At the receiving station, in addition to the usual tuning inductances, etc., some form of quantitative detector is required. An ordinary crystal detector (see an earlier page) is of this type, but in order to obtain greater sensitiveness a three-electrode valve (with reactive coupling) is preferable.

If a valve is employed and provided with reactive coupling between anode and grid circuits, this coupling, if too tight, will cause the receiving set to oscillate, in which case the steady emission (or carrier-wave) from the distant transmitter will give rise to beats and a corresponding note in the telephone receivers. Under these conditions reception of speech is impossible except in the exact resonance or silent point, and even then there is much undesirable distortion of the received speech, etc. Further, the reception of the speech, etc., by adjacent receiving stations is interfered with as the radiated waves from the oscillating receiver form beats with the carrier-wave to which such adjacent stations will, of course, be tuned. A reactive coupling may be used, however, and with good effect, but once the carrier-wave is heard and the note tuned down to silence-point, the coupling should immediately be loosened until the receiving set is just short of oscillating. As this alteration of reactive coupling will incidentally cause some variation in tuning, a slight readjustment will be necessary, particularly as the tuning for continuous waves on short wave-lengths is very critical.

For satisfactory reception of radio-telephony from low-powered stations at considerable distances, the addition of amplifying valves (either high- or low-frequency, or both) is advisable and usually necessary.

The inductance coils and variable condensers forming the tuned receiving circuits should be capable of very fine adjustment and should preferably have long insulated control handles to obviate the close approach of the operator's hand, which, on account of added capacity, causes an appreciable variation in the tuning.

GENERAL ADVICE

Every reader starting experimental wireless telegraphy is advised to obtain a copy of the official "Handbook for Wireless Telegraph Operators," which can be purchased through any bookseller. It contains a great deal of very useful information, together with the official rules and regulations pertaining to the operation of wireless stations, and also a copy of the International Morse Code and List of Abbreviations used in signalling.

LIST OF WIRELESS STATIONS

The list of stations on p. 31, though by no means complete, will prove of assistance in identifying received signals, and as it will generally be desired to know to what particular station certain received call-letters belong, the call-letters are placed first in the list.

Repairing Wooden Floors and Stairs

Cutting an Opening in a Floor.—It is sometimes necessary to inspect, repair or alter pipes, fittings, electric light casings, bell wires, etc., that are under floors or in the thickness of floors between the joists. The run of the pipes, etc., may usually be determined by finding two points where they appear in the same space (a room, for instance) and taking the most direct line between them. In the case of leakage from pipes, naturally this will show itself by damage to ceiling or floor. Generally, pipes, wires, etc., are run in the same direction as the joists, that is, at right angles to the length of the floor boards; otherwise, running of the pipes would entail extra expense in labour for cutting each joist for the pipe to pass and also would weaken the joist. In deciding the exact position of the hole, always consider the convenience of the user of the room, the best position as a future inspection point, and the avoidance of any disfigurement of the floor by cutting at a conspicuous place. The floor should be well swept before sawing.

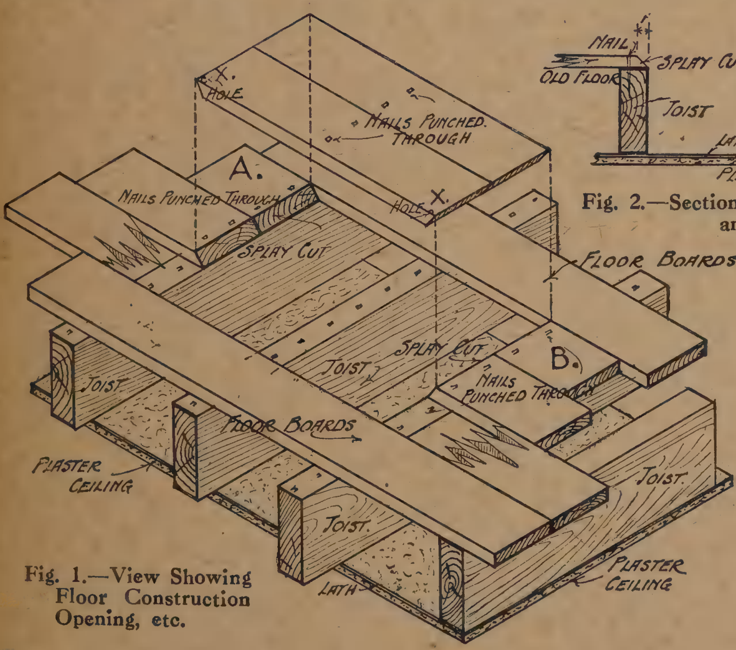


Fig. 1.—View Showing Floor Construction Opening, etc.

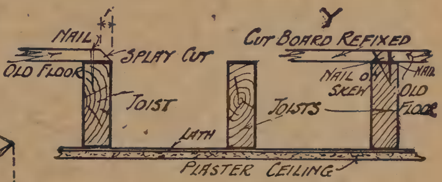


Fig. 2.—Section Through Floor, Joists and Ceiling

Fig. 1 shows how the floor should be cut, the two cut boards being shown raised above the hole. The first thing to do is to punch (with centre punch and a fairly heavy hammer) through the floor boards all nails which are likely to be encountered in the sawing, as also those on the centre joist, to enable the cut boards to be taken out. A slanting hole is then bored with a brace and $\frac{1}{4}$-in. centre-bit, through the floor board, at the points X X (Fig. 1). This hole should be as small as conveniently possible, so as not to damage the floor unnecessarily, and to make more easy the plugging of the holes afterwards. The position of the centre-bit hole will be determined by the positions of the nails in the floor boards, these giving approximately the centre of the joists underneath; and by taking 1 in. to $1\frac{1}{2}$ in. along the length of the floor board, a point coinciding with the edge of the joist would be found, against which the under edge of the sloping or splay cut should run. It is easy to know whether the hole is over the joist, as if, after boring 1 in. to $1\frac{1}{2}$ in. deep, the bit does not drop through the floor board, it is obvious that it is passing into the joist. However, care should be exercised to bore the hole for the first time in the correct place, though $\frac{1}{4}$ in. to the other side of the edge of the joist would be better than on top of it.

The top small end of a pad saw or keyhole saw is inserted in the hole thus made and sloped at an angle of, approximately, 45°. It is then worked along a line previously marked square to the edge of the board to be cut. Care must be taken to keep the saw at the same slope throughout the length of the cut. The sawing is repeated at the other end of the boards to be removed. The second cut can be over one or more joists, or, as in Fig. 3, between two of them.

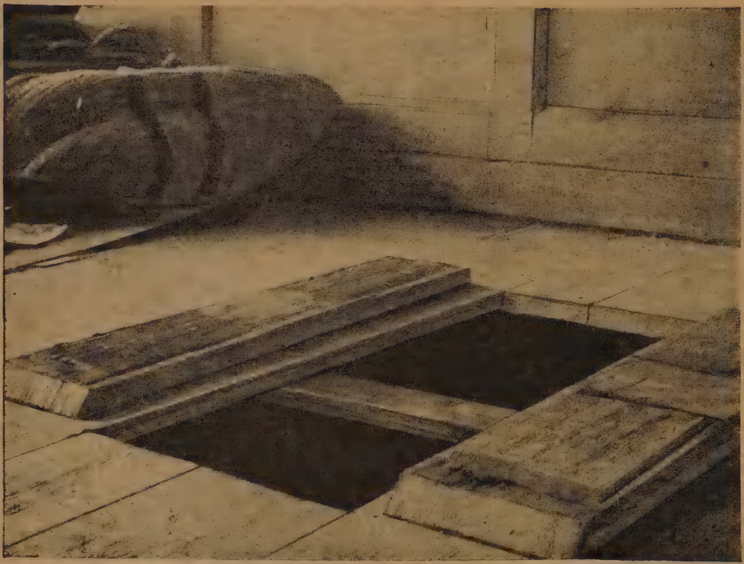


Fig. 3.—The Cut Floor Boards with Splayed Ends

Fig. 2 shows at Y the re-fixing of a board, the nails being inserted on the skew or slope through both boards, and into the joist. Screws, instead of nails, may be used in the same way, and are in many cases to be preferred, especially if the hole made will be useful as a future inspection point.

In Fig. 1 the board is depicted broken away to make more clear the splay saw-cut corresponding with the edges of the joists.

By opening the floor in this way its stability is in no way impaired, it is injured to a minimum extent, and the job is done in a workmanlike way.

Repairing Defective Floor Boards.—To execute properly and efficiently the repair to a worn or defective floor, the following instructions should be closely adhered to. Indicate with chalk lines on the floor the extent to which renewal is necessary; these lines must be parallel to

the joists and at right angles to the lengths of the boards. Punch through the thickness of the boards any nails likely to be encountered in the cutting, and then

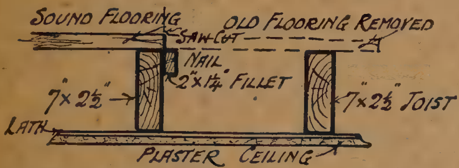


Fig. 4.—Section Through Floor Joists, etc.

well brush with a wire brush or hard broom to remove dirt and grit from the boards, so as to avoid any unnecessary damage to the saw. Work of this kind is always done at some expense to the tools used. The centre of the joists is prac-

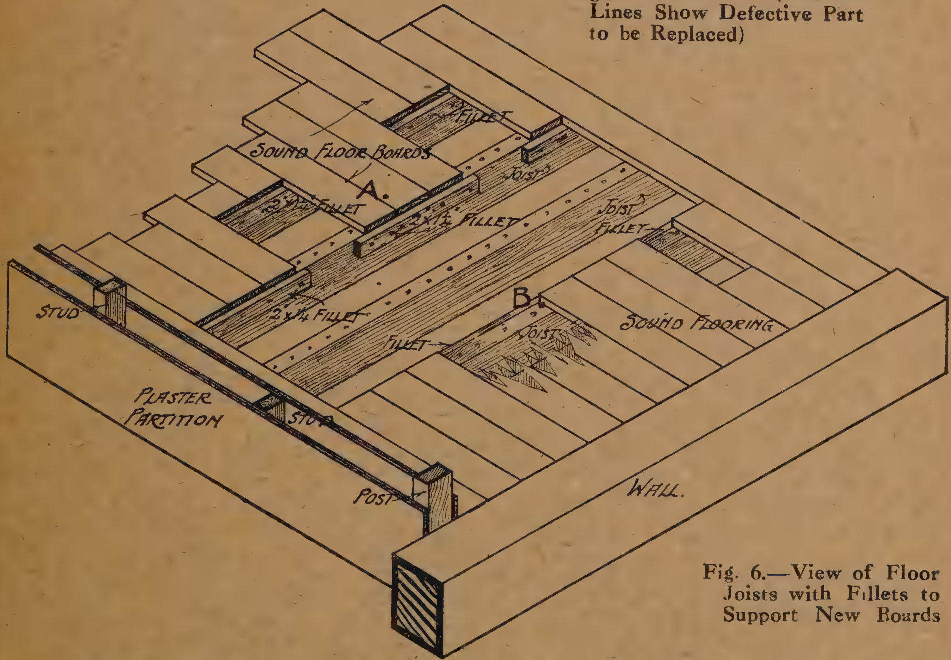


Fig. 6.—View of Floor Joists with Fillets to Support New Boards

tically the line of the nails, and by measuring 1 in. to $1\frac{1}{2}$ in. along the length of the floor boards the side of the joist underneath will be ascertained. Then bore a hole (with a centre bit and brace) in the board to be removed, as shown at points x x, Fig. 5, which illustration also shows by hatched lines the part of the floor which is assumed to be defective. Having ascertained the exact position of the side of the joist, it should be indicated

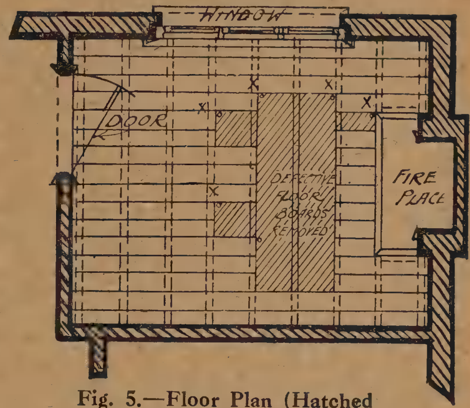


Fig. 5.—Floor Plan (Hatched Lines Show Defective Part to be Replaced)

by means of a line marked deeply with a knife.

It usually makes a more satisfactory piece of work if the floor boards cut are not to the same joist for too great a length, the joints being "broken" as shown in Fig. 6.

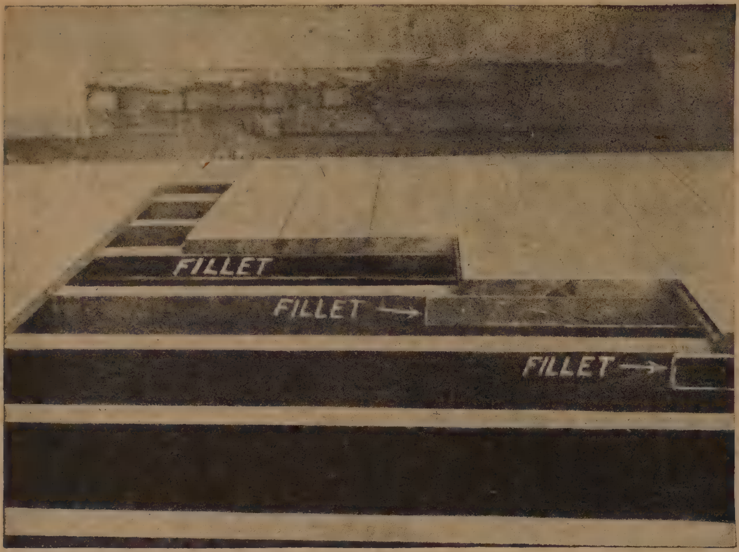


Fig. 7.—Opening in Floor Showing Fillets to Support New Boards

The line for the saw cut having been clearly marked, insert a keyhole or pad saw, and then cut so far as to enable a hand saw to be insertec with which to complete the cut. Be careful not to take too long a stroke with the saw, especially in the case of upper floors, because there is only the thickness of the floor in which to work and there is a great risk of damaging the ceiling underneath.

The whole of the cutting having been carried out in like manner, and the boards removed, knock down with hammer all nails, and trim and generally prepare the ends of the old boards with a sharp chisel ready to receive the new boards. They generally require a little attention at angles.

Fig. 7 is a photograph showing a floor cut up for renewal; the single board on the left-hand side has been taken up to an original joint, thereby avoiding the boring of the floor as previously described. The method of removing a board when it occurs in this convenient position is first to punch through all the nails on the four or five joists nearest the end, then to raise the end by leverage, and to place a piece of wood across the opening formed, to prevent its falling back again; then the remainder of the board is easily wrenched away.

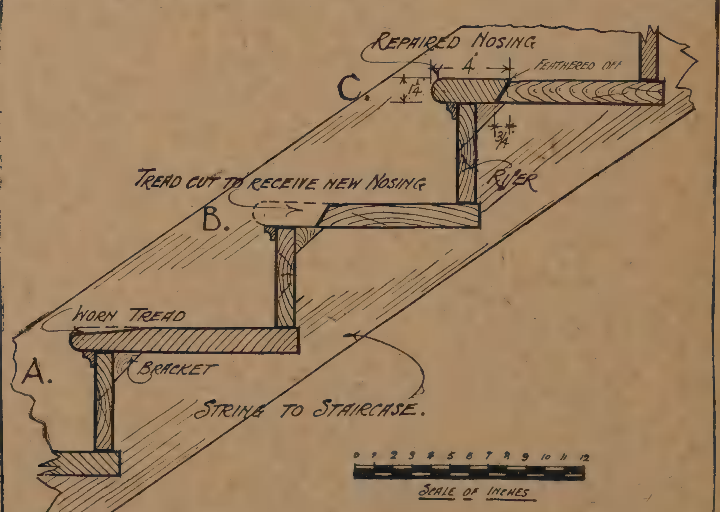


Fig. 8.—Section Showing How a Wooden Staircase is Constructed, and Indicating Worn Parts to be Renewed

The new floor boards will be supported on fillets nailed to the sides of the joists. The fillets are 2 in. by $1\frac{1}{4}$ in. in cross-section, and the nails should be stout and

Fig. 9.—New Nosing Ready for Fixing

$2\frac{1}{2}$ in. long. Figs. 4 and 7 show the fillets flush with the tops of the joists.

By punching down the floor brads and cutting through the old boards with a tenon saw, after raising them slightly by leverage, the provision of fillets is obviated, the new boards resting on the joists direct.

In replacing the new flooring the exact length should be taken for each board, and it is not wise to cut, say, four or five the same length before fitting the first. To cut, fit and fix one board at a time is much more satisfactory. Floor boards of the same width as the old ones should be obtained so as to avoid a patchy floor as much as possible. The fact that the new boards are not of the same thickness as the old ones may possibly give trouble; but it is easily overcome by packing up the boards or slightly cutting or planing them where they come over the joists. A slightly thinner board gives less trouble than a thicker one, as it is easier to " pack up " than " thin down " over joists.

A special word of caution: Renewing part of a floor in this way is seldom a satisfactory remedy in a case of dry-rot, as the remaining timbers are almost sure to be infected with the spores of the fungus. If removal of all the timber is out of the question, see that all timbers and boards —old and new—are liberally treated with a solution of corrosive sublimate or with solignum. That will considerably help.

Repairing Worn Stair Treads.—Fig. 8 shows a staircase in section. As will be seen, it consists of a string or side piece of wood usually $1\frac{1}{2}$ in. to 2 in. thick, into which is cut in or housed the treads and risers. These are wedged up, glue blocked, and bracketed together. The treads have rounded front edges forming the nosing, and a bead moulding is placed under same to improve its appearance and to cover the joint. At A the lowest tread is shown to be worn, and it is this front portion which should be renewed. The first operation to reinstate this portion of the tread is to cut the nosing diagonally with the tenon saw. A similar cut is made at the other end of the tread just beyond the worn portion. Next chip out this worn portion between the saw cuts with a firmer chisel and mallet, taking care not to split the tread beyond a line adjoining the two back extremities of the saw cuts. The surface at the back should be finished regular and smooth by paring with a 1-in. to $1\frac{1}{4}$ in. chisel. At B this is splayed outwards, so as to form a good bearing for the new nosing to rest against. Obtain a true surface with the chisel to ensure a good joint at this point. The section of the piece of wood removed is indicated by

Fig. 10.—Skew-nailing New Nosing

dotted lines. It will be obvious that to cut down square at the back of the new piece of nosing to be inserted would not make nearly so firm a piece of work.

The preparation of the new piece of wood is the next consideration. This should be a selected, close-grained, hard piece of wood, and planed to the exact

Fig. 11.—Slope or Slant Taking Place of Dangerous Step

thickness of the existing tread taken at the splay cuts made with the tenon saw. The edge should then be rounded with the aid of a smoothing plane, the piece of wood being firmly held in a vice. It is not advisable to run too long a length at once, as the thickness and section of the rounded portion varies a little, which should be allowed for and worked to for each step. Having completed this, the angle of the back splay is taken in the bevel from the existing tread, and transferred to the ends of the piece of wood being prepared. Lines should then be drawn on the face and at the back of it, connecting these points so obtained, and the piece of wood planed to them exactly with the jack plane. The angles of the splay cut made with the tenon saw should then be transferred in a similar manner, from the stairs on to the new section of wood, and the length between the same at back by means of a 2 ft. rule. Through the positions so found a square cut with the tenon saw should be made.

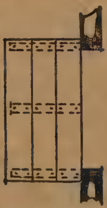


Fig. 12.—Plan of Slope or Slant

It is clear that a piece of wood the shape and size exactly of the hole cut in the tread is now prepared; and in Fig. 9, on the third step up, one piece so shaped is shown ready to be inserted. It is fully dimensioned and shown at C (Fig. 8) for this exact tread; but naturally it will vary slightly in width and length according to the defective nature of the tread being dealt with. It will be noticed that the new section has a bearing on the top of the riser on the bed moulding and the blocks and brackets, together with the support of the splay cut on the existing tread at the back.

After carefully adjusting and fitting this in position and feathering off the back edge slightly, so as not to leave a sharp arris or ridge at this point, it is skew-nailed (see Fig. 10) to the existing tread at the back, and nailed ordinarily in front into the riser.

The feathering off at the back of the new section of wood is shown at C (Fig. 8). The nails most generally used are oval brads, and those about 2 in. long would suit the purpose. Care must be taken not to split the new nosing, and if there is any question or risk about so doing, bore the holes required with a bradawl first, and then drive in the nails.

In most cases the worn portion of the step is in the centre (2 ft. to 2 ft. 3 in. wide); but sometimes it is worn quite up to the balustrade and wall string. In this instance, instead of making the splay cuts, the new portion runs through the whole length of the tread, and the rounded nosing is worked on the outside end or mitred at 45° with the existing tread at this point.

How to Remedy a Dangerous Step.—A bad arrangement, to be found, unfortunately, in a great many houses, is for a

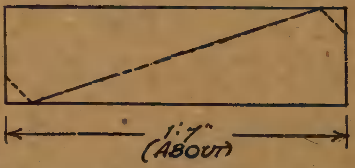


Fig. 13.—Cutting Two Supports from One Piece of Wood

single step to lead down into a kitchen or scullery, or to cross a passage, the lighting of the doorway or passage being frequently of the worst. Usually the con-

struction is accounted for by falls in the ground level, but it really is very ill-advised, inasmuch as it forms a trap for the unwary, a single step being so much less noticeable than a short staircase. Probably, the only means by which it is possible to improve upon such a step is to convert it into a slope, and this can be readily done by fixing a series of ordinary floorboards on triangular supports, as shown in Fig. 11. where the step and boards are, of course, shown in cross-section. A small corner is cut off the support in order to clear the projecting nosing of the step. At the bottom edge the boarding had better be rounded off, and splayed underneath to meet the floor as at A. The slope should not be greater than as shown in this figure, namely, 20° or about 1 in 3.

Fig. 12 is a sketch plan of a slope fitted to a door opening, the dotted lines indicating the underneath supports, which should be about $1\frac{1}{2}$ in. thick and spaced not more than 1 ft. 6 in. apart. Fig. 13 illustrates how two such supports can be obtained economically from one rectangular piece of wood by a diagonal saw cut (see the long dotted line).

A slope of this kind is an advantage wherever trucks, barrows, etc., have to be negotiated over stepped levels, but in the event of the same idea being adopted for a greater length than is required by one step, it will be advisable to nail on a few small fillets (oak for preference) across the slope at intervals to give a secure foothold. The timber used for boarding slopes needs to be of the best, and with its grain at right angles to the line of traffic. Practice shows that poor timber, especially if running in the direction of the traffic, rapidly wears out, and frequently provides splinters which become driven into the soles of the passengers' boots.

Doormat Sinkings.—The ordinary doormat, unless exceptionally large and heavy, is easily displaced, especially if resting on linoleum. To obviate this trouble a method that is often convenient is to form a frame of such a size as loosely to fit the mat. The frame is mitred at the corners as in Fig. 14, and composed of a fillet something like Fig. 15 in section, this being screwed to the floor. Oak is very desirable for this fillet, since it is certain to receive hard wear. Where comparatively rough usage may be expected, it will be advisable to use a fillet of rectangular section, with the outer top corner rounded off, and the angles halved together (see Figs. 16 and 17).

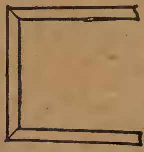


Fig. 14.—Part Plan of Doormat Frame

Fig. 15.—Section Through Part of Frame

Fig. 16

Fig. 17

Figs. 16 and 17.—Plan and Elevation of Halved Joint

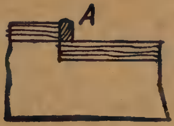


Fig. 18

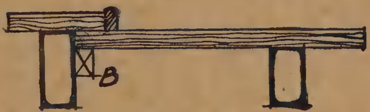


Fig. 19

Figs. 18 and 19.—Two Cross Sections Through Doormat Sinking

Often, however, a sinking in the floor is the only alternative to placing the mat farther from the doorway, or completely outside it. The sinking-in involves much more work, but results in a better class of job. Assuming a boarded floor, first the boards are taken up over the affected area, about $1\frac{1}{4}$ in. is cut off the upper faces of the floor-joists thus exposed, their tops being finished as nearly level as possible to receive the recessed boarding, and the old surrounding flooring is next made good up to the margin of the required space, which is bordered with a

small fillet rounded on top as at A in Fig. 18, and mitred at the corners. This figure is a section taken on a line parallel with the floor joists, showing the old and new levels of boarding, which will be supported on the joists without difficulty in this direction. In Fig. 19, it will be seen how it may very possibly be necessary to continue the ends of the new boards farther than the recess under the higher boards, until they meet the next joist, wherever this happens to come, when they can be supported upon a fillet nailed firmly on the side of it, as at B.

Methods of fighting dry-rot in floors are explained elsewhere in these volumes.

Erecting Fittings on Tiled, Marble and Glass-lined Walls

THIS used to be a very difficult proceeding, and unless carried out by a highly skilled workman was generally done badly. One of the best of the old methods, in the case of a tiled wall, was to nip off one corner of each of four adjoining tiles so as to form a little hole through which the screw could pass to a wooden plug inserted in the wall behind the tiles. Generally there was a little washer under the head of the screw to assist in holding the tiles to the wall, and this method was commonly adopted for holding tiles to a wooden background as in the case of a wash-hand stand, etc.

This method had the obvious disadvantage that a screw could only be inserted where four tiles intersected, as it were, and that in the case of a wall already tiled some of the tiles had to be removed with an almost certain risk of breakage, or the work done under conditions of extreme difficulty or inconvenience.

A newer and more satisfactory method is to use a Rawlplug tool and start a hole, exactly where it is required, by very light hammering so as to scratch or break the glaze on the face of the tile. Once the glaze is cut through, the work is carried forward by putting the Rawlplug jumper or bit in a brace and boring out the hole; perhaps a little turpentine will lubricate the tool and assist the boring. Exactly the same method answers for marble, stone, etc., except that there is no glaze to cut through, though it is still advisable to start the hole with hammer and tool.

The hole having been made, a Rawlplug (a little tube made of jute) is slipped into the hole, the fitting put in its place, and the screw inserted.

In fixing Rawlplugs in glass, a different method must be adopted. A very hard ("glass-hard") steel drill may be used with extreme caution, and the boring bit lubricated with turpentine. This is a laborious method, and a certain proportion of failures will be met. A more reliable method of drilling a hole in glass would be to use a copper tube corresponding with the size of the hole required, to drive this with a brace (better still, with a geared hand-drill), and to feed the tube with new, sharp emery and oil. Naturally the job takes time, and patience and caution are alike necessary.

Slating a Shed Roof

SLATING consists in overlapping the tops of one row of slates with another row to a certain determined depth, in order to break joint, and this operation is repeated until the work is finished. The lap is the most important part of slating, and it varies according to the gradient of the roof; a lap, for instance, that would be suitable for a roof with a gradient of 1 in 6, could not be used when the gradient

is 6 in 1. And, again, a lap that would be sufficient for any ordinary rainfall would be defective in very violent rain.

Slates vary in size from 13 in. to more than 36 in. in length. The size should always be mentioned in inches. Up to a certain size they are sold by count (120 to the 100) or by the square, beyond which they are sold by weight, and are called "ton" slates. For the former, the lap is from 2 in. to 4 in.; and for the latter up to 6 in. The largest and thickest slates should always be used at the bottom of the roof, the smaller and lighter ones being worked up to the top.

A slater's tools are few in number. A slate-knife, a pickhammer with claw, a 2-ft. rule and a straightedge correctly ruled for gauging, a dressing block, consisting of a piece of 1-in. by ½-in. or 1½-in. by ¼-in. iron about 2 ft. long, with the ends sharpened and turned down about 5 in. for driving in a block, a slate-ripper, a trowel, and a chalk line constitute an ordinary outfit.

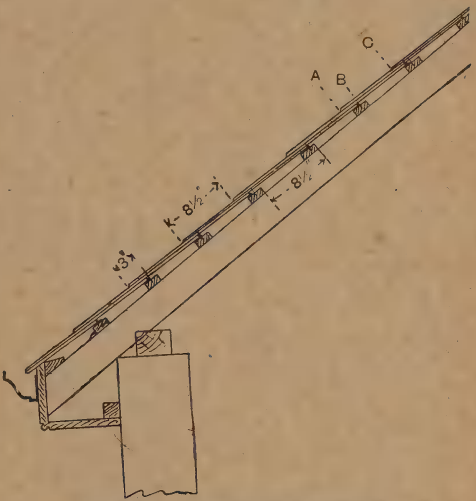
All slates should be nailed at the shoulder with two nails, one on each side. They should be holed from the bed side, so that when the hole is made, sufficient slate is knocked off the surface to allow the nailhead to lie flush with the surface of the slate. The side of a slate where the edges are roughly chamfered is the surface.

To hole slates with uniformity, a gauge is required, and the ruled straightedge is generally used for this purpose, but a stop must be placed on it. A temporary one can be made from a piece of batten about 2 ft. long; drive a nail through it at a distance of 15 in. from one end; and, for holing 24-in. by 12-in. slates at 13½ in., measure 13½ in. from this nail, and at this point drive another partly through to act as a marker. With this gauge the slates can be accurately and uniformly marked, and may then be holed with a machine or with a slate-knife or slate-hammer.

There are various kinds of slate nails, malleable, light and heavy clouts, zinc, etc. Malleable and light galvanised clouts corrode in a few years. Heavy galvanised clouts, or copper nails, should be used on buildings exposed to chemical fumes.

The following instructions apply to the slating of a shed or similar roof, using 20-in. by 10-in. or 22-in. by 12-in. slates. The illustration shows a method of laying slates on battens, the distance between A and B being the lap, and that between A and C the gauge.

The width of slate exposed is called the "gauge," its width diminishing as the lap increases. The gauge for any kind of slating is found by deducting the lap from the length of the slate, and then halving the remainder; thus, if countess slates



Section Through Slated Roof

are laid with a 3-in. lap, the gauge will be $\frac{20-3}{2} = 8\frac{1}{2}$ in. Each course of slates "breaks joint" with the one below it. The first course the slater lays is little more than half the length of the course which is intended to cover it, and is necessary to break the joints at the eaves. This is called the doubling eaves course, and the covering eaves course is brought to the same foot line completely to cover it. The gauge or margin is set up from the foot of the eaves course at each end, and a line strained to mark it along the whole length. The distance apart of the battens at the top edges being 8½ in., these distances are set up to the ridge, when another half course completes the work.

Metal-turners' Lathes and Accessories

Principle of Metal Turning.—As far as the fundamental principle of turning is concerned, no change has taken place from the time when crude lathes were first used to the present day, when machines of a very complicated nature and bearing little resemblance to the primitive machines are still designated "lathes." In very early times the work was revolved between rough centres or points by means of a cord and weight, or by means of a bow; in modern machines the work is revolved between centres, or by some form of power while being held in a chuck. The principle of turning in a lathe remains what it always has been, that of rotating the work on its axis while being cut by a tool.

The development of the modern lathe can be attributed directly to the invention by Henry Maudsley, early in the 19th century, and subsequent application of the slide-rest, prior to which turning was chiefly done by means of hand tools.

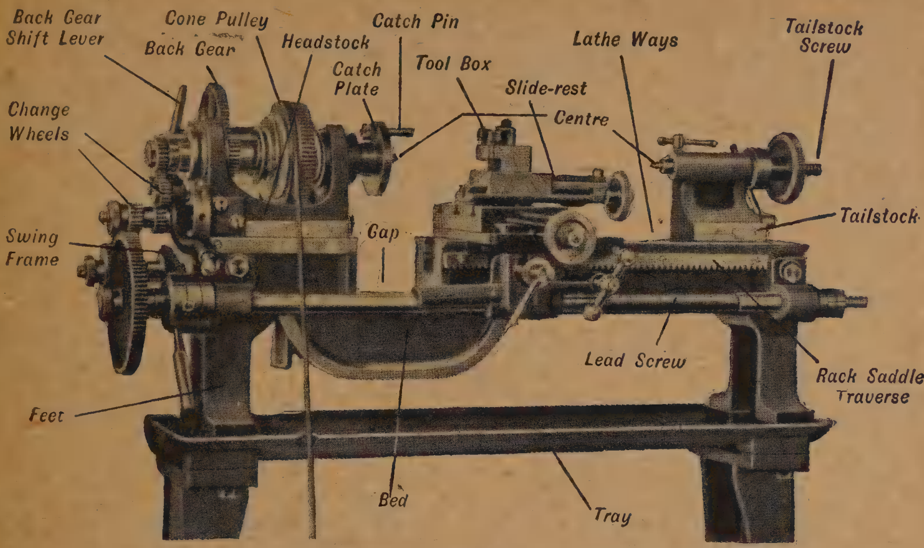
Sliding, surfacing, and screw-cutting lathes are the types most used by metal-workers, engineers, and others. The term "sliding" indicates that the saddle can be automatically traversed along the bed, and the term "surfacing" points out that the tool and cross slide can automatically be traversed at right angles to the bed. The word "screw-cutting" is used to denote that the lathe is fitted with a leading screw and can be used for cutting threads.

CHOOSING A LATHE

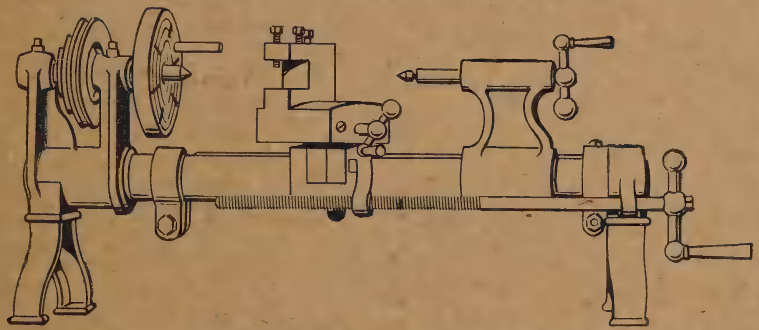
For ordinary use it is not necessary to buy either a very heavy or expensive lathe, and generally a 3½-in. to 4½-in. centre lathe should be large enough. A lathe with a gap in the bed is very desirable, as this permits such objects as flywheels to be turned without any trouble. Very little exertion is required when using a treadle lathe, if care is taken in choosing a well-made article. The crank should be fitted with a good flywheel, in order to give steady running, and if possible all the treadle motion should be fitted with ball or centre bearings. The lathe should preferably be fitted with screw-cutting mechanism, and also with a slide rest. A back gear should also be provided in order to allow of slow running, and to enable it to make fair-size cuts. Figs. 1 and 2 show a selection of small lathes—all of them modern—intended chiefly, but not solely, for amateur use.

DRIVING PLATES, ETC.

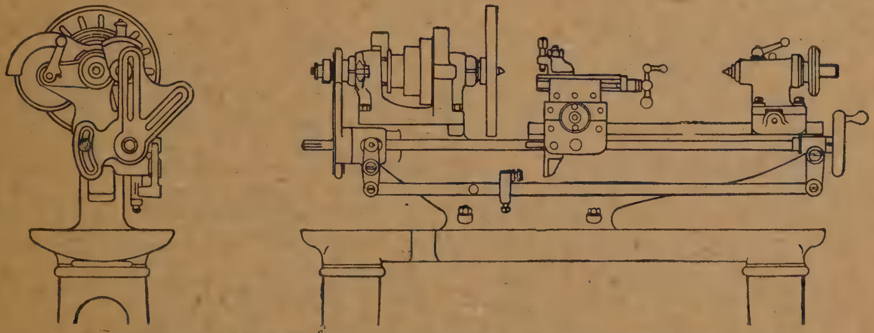
The Driving Attachment (Fig. 3) is most commonly used for small work, and is so arranged that the centre A can be taken out and a hollow centre fitted. It is usual for clockmakers to use a hollow centre, the pointed ends of the work fitting the hollow part of the centre. However, it is usual for engineers and metal-workers in general to use pointed centres which fit into recesses made in the ends of the work, and when in position the work is said to be "between the



A Typical Gap-bed Lathe (Milne) with its Parts Named



A Bar-bed Lathe (Velox $3\frac{1}{2}$-in. centre) with Simple Type of Slide-rest



Elevations of a Well-equipped Screw-cutting Lathe (Drummond $3\frac{1}{2}$-in. centre)

Fig. 1.—Three Small Modern Lathes

centres." In Fig. 3 the driving arm B passes through the spindle C, and presses against the carrier or dog that is fastened on the material that is being turned; as the lathe spindle revolves, the driving arm carries the carrier and the work along with it.

A Driver Plate (Fig. 4) is generally employed for any work above the sizes used in models, etc. The chuck plate A is screwed on the lathe spindle, and carries the driving peg B. This touches the carrier C, which is fastened, by means of the screw D, on the spindle E held between the centres F and G.

TYPES OF CARRIERS

The Straight-tailed Carrier (Fig. 5) consists of a cast-iron or malleable-iron frame A, through the hole in which the bar of iron passes and is prevented from slipping by means of the set-screw B.

The Bent-tailed Carrier (Fig. 5A) is made of drop-forged steel, the tail being oval to give additional strength: when a carrier of this description is used, the driving pin B (Fig. 4) is dispensed with, the tail passing through a slot in the driving plate.

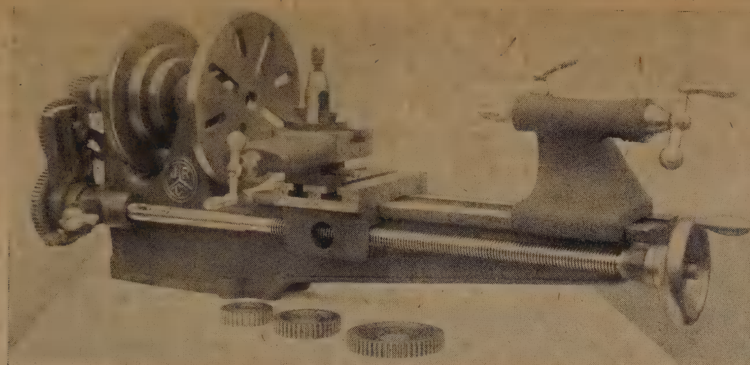
The Double Driving Carrier (Fig. 6) is particularly suitable for use with a special faceplate having two driving pegs instead of one, as shown by Fig. 6A; the advantages are that the two pegs equalise the strain and reduce the thrust upon the lathe centres; and further, the carrier clamping screw is in a position that prevents it being sheared off through improper use as a driver. It is claimed that better and truer work is produced by a two-tailed carrier; the sizes made will carry work from $\frac{3}{8}$ in. to 4 in. in diameter.

The Heavy Carrier shown by Fig. 7 is made of drop-forged steel, fitted with two clamping screws, and is intended to be used on high-power machines. The screws are no less than 1 in. in diameter, and the 5-in. size weighs 25 lb. It is not usual to use carriers of this description for work less than 4 in. or 5 in. in diameter; the position of the two clamping screws makes it impossible for the work to shift if the screws are properly tightened.

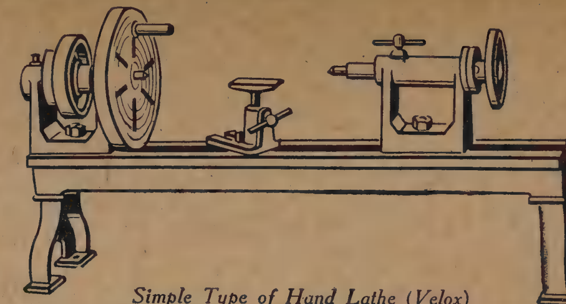
Adjustable Carrier.—The carriers already described have the objection that considerable time is consumed in adjusting the clamping screw or screws to each bar that is required to be turned. To save this loss of time an adjustable carrier has been placed on the market. It consists of two parts A and B (Fig. 8); the top part, fitted with the clamping screw, has three V-shaped grooves forged on each side of the inside portion. The corners of the V-shaped part of the lower half of the carrier fit into the grooves in the upper part in the manner indicated. When the clamping screw is released the carrier can instantaneously be adjusted within its limits, thus saving the screwing up or down of the clamping screw. A chain connects the two parts of the appliance together (see Fig. 9), and prevents the loss of either portion. Another advantage of this carrier is that it can be fitted on the bar after the latter has been placed between the lathe centres.

The Framed Carrier (Fig. 10) is very strongly made, and is useful for sizes up to $1\frac{3}{4}$ in. The sliding block A is made of hardened steel, and tightly grips the bar. The peg that projects from the driver plate (Fig. 2) can pass through the slot B, thus making an efficient drive. If desired, a small angle-plate can be bolted on the driver plate in such a manner that it presses against the tail C. A strong form of carrier is indicated by Fig. 11, and consists of a piece of rectangular steel A bent double, and then bent to the shape of a wide V. Through the slot or space between the bent portion is placed a forged piece of steel B, which carries two nuts, one at each end. As will be seen in the illustration, a strong grip can be obtained on the bar C.

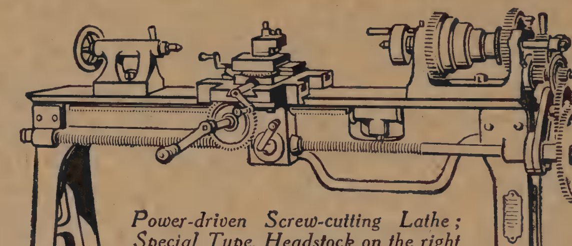
Carrier for Tapered Work.—It is sometimes found necessary to place a carrier on a piece of tapered work, and great difficulty is then experienced in using any of the carriers already described. Fig. 12 illustrates a special carrier fitted with a swivel jaw A. The tapered work B is placed in between the jaws A and C, and the nuts D and E screwed up. The



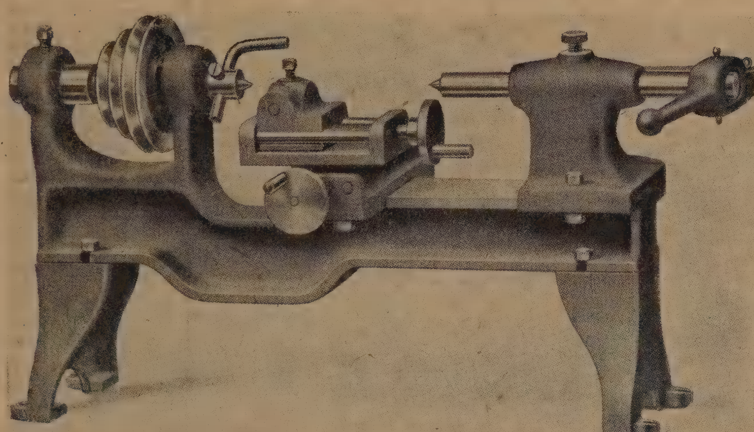
A Bench Lathe (J.R.C. 3-in. centre)



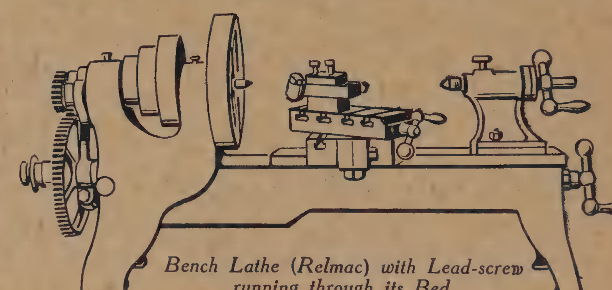
Simple Type of Hand Lathe (Velox)



Power-driven Screw-cutting Lathe; Special Type, Headstock on the right



A Quite Small Bench Lathe (Little Goliath 2-in. centre)



Bench Lathe (Relmac) with Lead-screw running through its Bed

Fig. 2.—Five More Modern Lathes

jaw A is so arranged that it turns on pivots in the bottom of the screw F, and so accommodates itself to the amount of taper on the bar.

CHUCKS AND FACEPLATES

In addition to the turning of cylindrical bars held between the lathe centres, as fully described, with many illustrations,

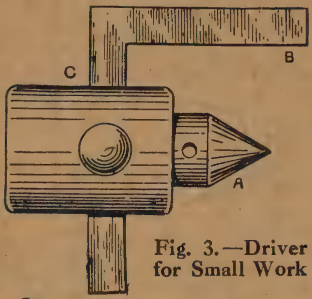


Fig. 3.—Driver for Small Work

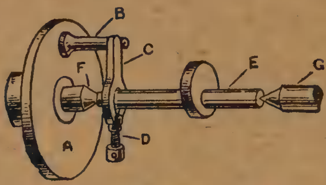


Fig. 4.—Ordinary Type of Driver Plate

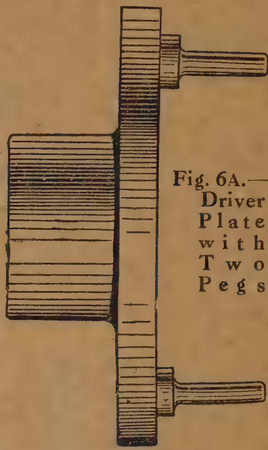


Fig. 6A.—Driver Plate with Two Pegs

Fig. 7.—Carrier with Two Clamping Screws

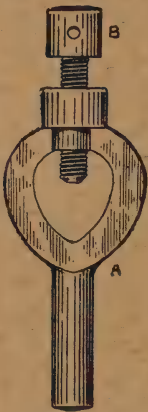


Fig. 5.—Straight-tailed Carrier

Fig. 5A.—Bent-tailed Carrier

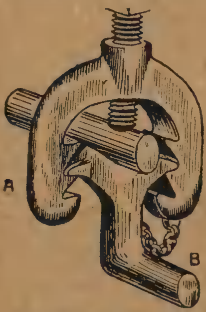


Fig. 8.—Adjustable Carrier

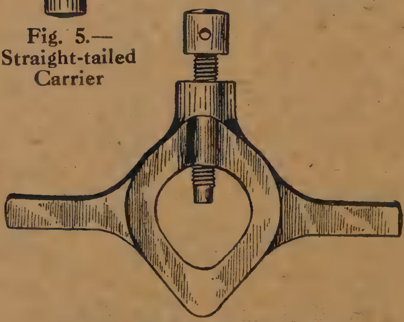


Fig. 6.—Double-tailed Carrier

Fig. 9.—Parts of Adjustable Carrier

Carrier for Large Material. — Another form of carrier or clamp-dog is indicated by Fig. 13. This is made of malleable iron in two parts, and connected by means of two clamping screws. A bent tail A is fitted on the lower portion, the tail fitting in a slot in the driver plate.

in a later chapter, much work can be done while held on a faceplate or in a chuck. The use of a faceplate for holding work is not recommended, but in many cases the work is so shaped that it cannot be held in a chuck. Many metalworkers do not fully realise the capabilities of the

modern chuck. There are many forms of chuck in use, being classified as combination, universal, independent, draw-in, etc.

A Combination Chuck is so arranged that its jaws can be adjusted singly, or, if desired, they can all be moved an equal amount simultaneously. This class of device is very useful, inasmuch as it can be used for holding irregularly shaped objects (its jaws being used independently), or for holding perfectly circular parts. Further, as two tools are combined, one chuck only is necessary instead of two. One disadvantage of the combination chuck is its relatively high cost; much accurate work enters into the construction, this causing expense in production.

Universal Chucks are so made that the turning of a screw moves all jaws, sometimes three and often four, simultaneously and each a like amount. This form of chuck is generally preferred for model making, etc. Generally speaking, when lathes are used by mechanics for small parts, such as those of model engines, motors, etc., a universal chuck is all that is required for boring and surfacing.

Independent Chucks are so called because the jaws are arranged to act independently of each other. Such chucks are useful when the work has an irregular outline, but are somewhat a nuisance for circular work. Many turners use an independent chuck because of its low cost, and when work is of an intermittent character its disadvantages need hardly be considered.

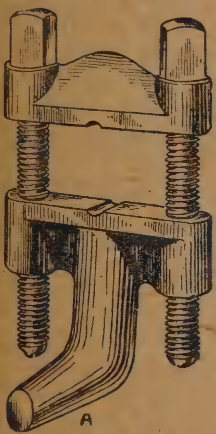


Fig. 13.—Carrier for Large Material

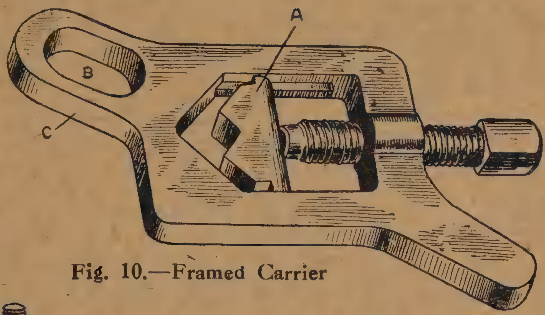


Fig. 10.—Framed Carrier

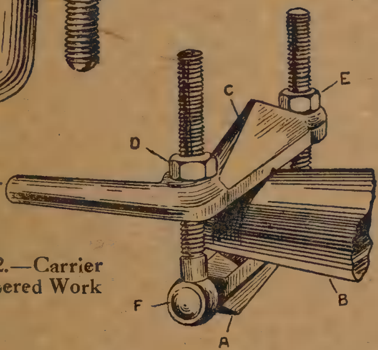


Fig. 12.—Carrier for Tapered Work

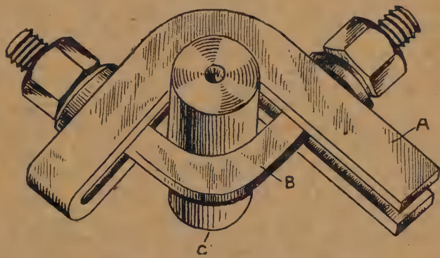


Fig. 11.—Carrier for Heavy Work

Draw-in Chucks are extremely useful and inexpensive appliances, which do not appear to receive the attention they deserve. Much work in the form of small screws, washers, nuts, etc., can be done with the aid of these chucks, thus dispensing with the centres. Another advantage of this type is that its use obviates waste of material, as, a carrier not being used, a spare length is not required, it being possible to work close up to the

chuck. Of course, with a draw-in chuck it is necessary that the lathe spindle should be hollow.

PRECAUTION IN USING FACEPLATES AND CHUCKS

The faceplate can be used for many purposes, such as for driving, for holding pieces of peculiar shape, for holding an angle plate, etc. In clamping an article on the faceplate it is advisable to place a piece of thin paper between the surface of the faceplate, and the bottom of the article to be machined. Especially is this so when the surface is very smooth. Many faceplates are irretrievably ruined by clamping heavy work on them and by using massive bolts. It is quite an easy matter to spring a faceplate out of shape by the use of a very large spanner for tightening up clamping nuts. The faceplate must be kept perfectly true; for this reason discretion must be exercised as to what use it is put. If a faceplate is slightly out of truth on its faces, it can be corrected by filing off a small amount from the boss that abuts against the spindle collar. The exact position can be determined by holding a piece of chalk up to the face of the plate while revolving; the out of truth portion will first touch the chalk. To true up the faceplate a small amount can be filed from the boss exactly opposite the chalk mark, but this method is not recommended.

In screwing on the nose of the lathe spindle, a combination, universal or independent chuck, or a faceplate, special care must be taken that the thread is not damaged, and that it is wiped perfectly clean before the device is screwed on. In screwing on, the chuck must neither be held against the nose as it is revolving nor bumped against the collar at the end of the thread; if this precaution is not observed the accuracy of the lathe will materially suffer, and it may become a difficult matter to remove the chuck.

Should the chuck become fast, it can be removed by revolving the lathe spindle backwards, and inserting a block of wood between one of the chuck jaws and the top of the lathe bed. In the case of a faceplate which has no jaws, a bolt can be inserted in one of the holes or slots, fastened by means of a nut, and the wood placed between it and the lathe bed. Should this method fail, it is advisable to warm the boss of the chuck or faceplate by means of a hot piece of iron or steel bent round the boss. Should a suitable piece not be available, a blow-lamp can be used. Care should be exercised in heating, so as to warm the boss evenly. The warming will slightly expand the material, and render easy the unscrewing from the nose of the lathe spindle. It is not wise to allow the necessity for such treatment to arise.

In screwing on these attachments, the lathe spindle must be completely stopped and no attempt should be made to screw on the faceplate or chuck while the lathe is running. If the chuck is placed fairly and squarely on the thread it is bound to get tightly wedged when it strikes the collar at the end of the lathe-spindle nose. There is also the possibility of getting the chuck cross-threaded on the end of the spindle. This will probably result in the chuck being thrown out of the hand, and perhaps personal injury.

The correct method of placing the faceplate or chuck in position is to hold the chuck vertically by the right hand, the bottom of the article really resting on the wrist. It will be found quite easy to hold the chuck vertically by this method. The left hand will be at liberty to pull round the belt, or to turn the lathe cones, thus turning the spindle and causing the chuck to screw itself up to the collar.

In removing chucks or faceplates, the cones should be prevented from revolving by one of the many methods (such as putting in the back gear without removing the pin), and the chuck or faceplate gripped tightly in both hands. Then, when a firm grip is obtained, the chuck or faceplate should be smartly jerked towards the worker, or, in other words, in the direction opposite to that of the rotation of a clock's hands. If it is found impossible to remove the attachment in

this way, one of the special methods already mentioned should be tried.

In drilling and boring, the work needs to be very accurately set on the faceplate; and in a later chapter will be found some special instructions applicable to this job.

CHUCKS FOR HOLDING SMALL RODS

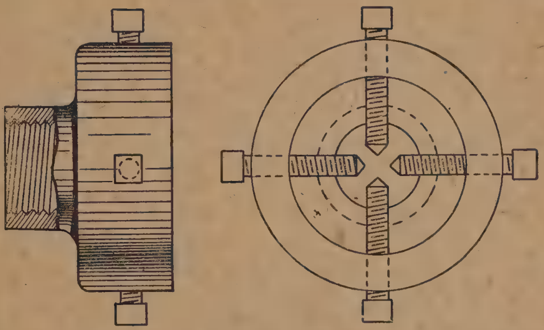
In the making of small screws, pins, washers, etc., it is often undesirable to place the work between the centres, this somewhat cramping the work. If short pieces are to be made, a number of small and effective chucks can be utilised; and, if the lathe has a hollow spindle, long rods can be used, thus minimising the waste that accrues from the use of short pieces.

Bell Chucks.—The writer does not recommend the use of a bell chuck (Figs. 14 and 15) owing to the projecting screws and the difficulty of rapidly setting work true; but occasionally its use cannot be avoided. Sometimes there are six or eight screws instead of the four shown. The bell chuck screws on the lathe spindle at the part shown broken in Fig. 14 (the two figures are not to scale).

Split or Draw-in Chucks.—If the lathe has a hollow spindle, a split or draw-in chuck, as shown by Figs. 16 and 17 can be used for very many purposes, including the holding of saws, drills, milling cutters, etc.

This chuck is for round bars, and is made of cast steel, hardened if possible, although for the ordinary metal-worker the soft material can be used. In use, the chuck is inserted in the hollow spindle, the part A being a good sliding fit and the taper B being exactly the same as that of the mouth of the spindle. The central hole C, in which the bar is placed, should be perfectly smooth and parallel, and very little larger than the diameter of the bar. Three saw-cuts, one of which is shown at D (Fig. 17) and all of them at E, F, and G (Fig. 16), are made in the front end of the chuck, so that when the chuck is drawn into the spindle by means of a screwed tube fastening on H, the front end, in the endeavour to slide along the tapered part, closes on the bar to be held. It is advisable to fit a key in the chuck to minimise the danger of its turning when the screwed tube is rotated. A groove will, of course, be necessary in the lathe spindle for the reception of the key.

When making small square-headed and hexagon-headed screws they can be cut from a bar of such a section that no machining or filing will be necessary to shape the head. If the head is to be of hexagonal form, the split chuck must be made to fit (see Figs. 18 and 19); and if the head has four sides the chuck must have a square hole (see Fig. 20). In Fig. 19 A is the hexagonal hole and B



Figs. 14 and 15.—Bell Chuck

the central hole of circular section roughly bored out. No other alterations in the design are necessary. Bright drawn material can now be procured having an error of ·002 in. only. Square and hexagonal nuts can be made without much trouble, while the material is held in a split chuck. The hole is first drilled and tapped, and next the nut is cut off by means of a parting tool.

Split Chuck for Use on Spindle Nose.—It frequently happens that small lathes are not provided with a hollow spindle, and in such a case it is necessary to devise a means of holding tools in a split chuck. Screws can be made from short pieces of bar held in this fashion; long pieces cannot be used, since there is no hole through the spindle. A split chuck. for use on the spindle nose, is

shown in longitudinal section by Fig. 21. A sleeve A having three slits at the front end is made to fit the tapered hole in the spindle, and a cap or nut B is screwed to fit the lathe mandrel and bored to suit a taper turned on the front end of the sleeve. The parts are shown separately by Figs. 22 to 25. In use the rod is inserted in the central hole, and the nut (Figs. 24 and 25) tightened up, this causing the split end of the chuck to grasp tightly the rod and prevent its slipping. A hole must be drilled through the front end of the tapered sleeve as shown at C (Fig. 21) in order that a pin can be inserted for the removal of the sleeve.

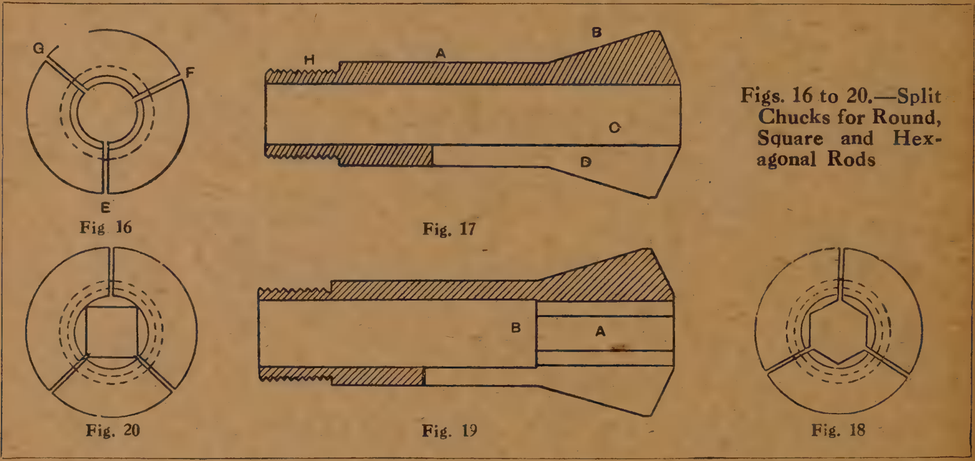


Fig. 16 Fig. 17 Fig. 20 Fig. 19 Fig. 18

Figs. 16 to 20.—Split Chucks for Round, Square and Hexagonal Rods

There are so many forms of split chucks that it is impossible here to describe all the shapes; but in every case the method of holding the work is similar to that shown in Figs. 17 to 21. In some cases the head of the split chuck has a square filed on it, and the other end is screwed to fit the lathe spindle. The mouth of the spindle has a taper opening, into which fits a corresponding taper turned on the periphery of the chuck. To tighten up the work, a spanner is placed on the square part and the chuck partly rotated. Other chucks have a screwed tapered end, on which fits a nut. The two forms of split chuck just mentioned are suitable for small-size work and for intermittent use; but they are not recommended for regular usage.

Drill Chucks or Holders.—For holding small drills and other small tools in the lathe, a simple form of chuck, made from one piece of material, can be employed. Fig. 26 shows a piece of mild steel made to fit the taper hole of the lathe spindle. The drill A tightly fits the circular hole, and the tang fits between the two circular steel pegs B and C driven in the chuck. It is advisable to provide a small hole D in the chuck near the end of the drill, so as to facilitate its removal.

A simple and easily made drill holder or chuck is shown by Fig. 27. The circular drill shank tightly fits the hole, and the flat of the tang on the end of the drill snugly fits the flat of the cut-away portion A. A disadvantage of this type is that the tang of the drill is sometimes twisted off; but if the tang is carefully tempered and not made too hard, this may be avoided. For some classes of work the socket (Fig. 28) may be used. It is made from a piece of bar mild steel, and bored taper to fit the shank of the drill. If carefully made, and if the drill tightly fits the taper, there is little chance of its slipping in use when drilling holes of moderate size.

Four-jaw Chuck.—The four-jaw chuck has not much more than a theoret-

ical interest for most amateur turners ; but it may suitably be referred to in this place. A chuck of this type, adapted for use on a $5\frac{1}{2}$-in. centre lathe, is illustrated by Figs. 29 to 32, of which illustrations Fig. 29 shows a half-plan of the jaw chuck with one jaw removed ; Fig. 30 is a part back view of the body.

This chuck is fitted with reversible jaws which slide in a shallow groove on the front of the face of the chuck, and to reverse the jaws it is only necessary to slacken the $\frac{5}{8}$-in. nuts at the back of the chuck sufficiently to allow the jaws to clear the shallow groove, when it can readily be reversed. It will be noticed that to do this the screw must lift up with the jaw, and this is effected by the bearings of the screw being open to the face of the chuck ; this is shown clearly in Figs. 31 and 32. The body of the chuck is of cast-iron, the jaws are forged from double shear steel, and the screw and nut are of mild steel. The nut is 1 in. thick, and the screw $\frac{3}{8}$ in. square threaded. The part on which the jaw swivels is solid with the nut, and is $\frac{13}{16}$ in. in diameter. The next diameter above is $\frac{5}{8}$ in. The circular nut is tapped $\frac{1}{2}$ in., and screws tightly on its thread and jambs hard on the shoulder, just clearing the recess in the jaw by one-thousandth of an inch. The jaws should move stiffly on the pin ; no slackness is permissible. This type is superior to that in which the nut and jaw are solid, because to reverse the jaws it is necessary to remove the screw entirely ; and should the thread have been strained, it will be found impossible to enter the screw at the opposite end for a reversal.

THE SLIDE-REST

The slide-rest supplies a mechanical means of applying and guiding the cutting tool. The great superiority of its use over handwork is caused by the rigidity with which the tool can be held, and the true guidance of the tool in the line of the cut required. The straight line of guidance is given by the slides, and it is absolutely necessary that these slides should be mechanically straight and true, and also that the parts which slide on them should move freely and have long bearing surfaces, be easily worked, and be quite free from the least suspicion of shake.

As the lathe is intended to impart to the work placed therein true circles, straight lines and flat surfaces, it follows that these conditions must first exist in the tool itself, because a tool cannot convey more accuracy to the work than is possessed by the machine or slide that guides it. It is important in a slide-rest

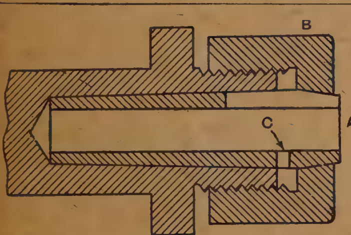


Fig. 21.—Section of Chuck for Spindle Nose

Fig. 22 Fig. 23

Figs. 22 and 23.—Split Sleeve

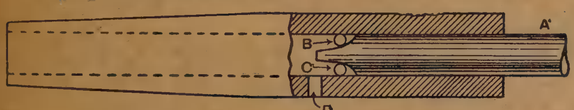


Fig. 26.—Simple Drill Chuck

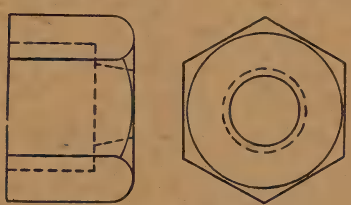


Fig. 24 Fig. 25

Figs. 24 and 25.—Nut for Chuck

that a means be provided for getting the "straight line" absolutely at right angles to the axis of the lathe mandrel; upon this depends truly parallel cylindrical work, and also true and flat work on face-plates, the shoulders or collars, flanges, etc. The average slide-rest on lathes that are not screw-cutting is faulty in this particular, due to the common form of slotted bed into which fits a tongue of the slide-rest which is made an easily sliding fit with no means of taking up wear, and it can therefore afford nothing more than approximately true setting of any of the slides dependent on it.

The slide-rest should be compound, by which is meant that it should possess two slides—one that will face work on the faceplate (this slide is then at right angles to the lathe mandrel), and another that will work parallel with the centre line of the mandrel and also swivel round for taper work. It should be marked on the circular flange with a zero, indicating

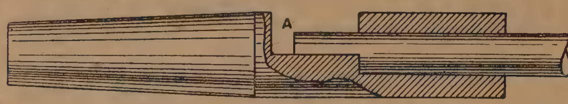


Fig. 27.—Chuck with Flat for Driving

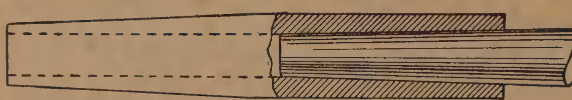


Fig. 28.—Chuck for Taper-shanked Drill

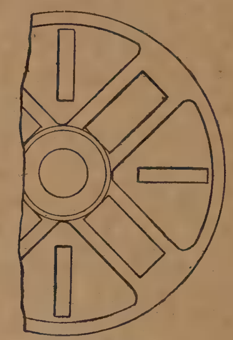


Fig. 30

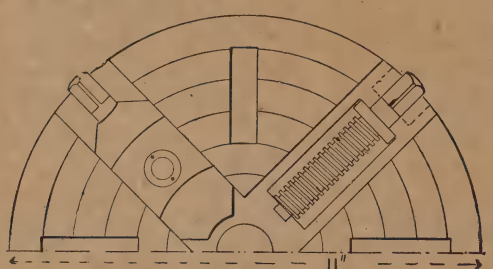


Fig. 29

Fig. 29.—Half-plan of Four-jaw Chuck, with one Jaw Removed

Fig. 30.—Part Back View of Body of Chuck

Figs. 31 and 32.—Details of one of the Jaws

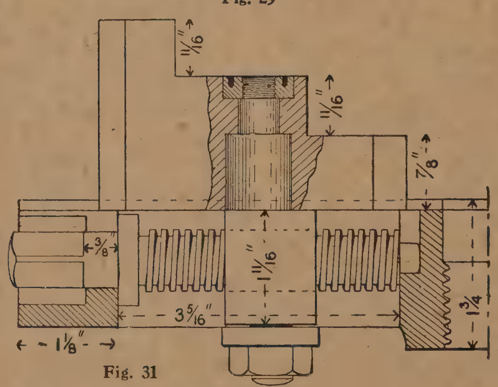


Fig. 31

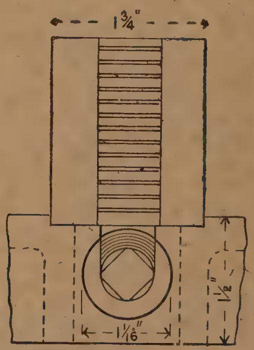


Fig. 32

when the slides are at right angles to each other, and there should be degree marks on each side of the zero mark for the purpose of taper turning on short work between centres or in the chuck; these marks are indicated in the photographs (Figs. 33 and 34). The screws that operate the slides should be of steel and have square threads with detachable gunmetal nuts; they should be protected from dirt, chips, etc., by the use of extra long moving slides, or by arranging the screw in front of the slide as shown in Fig. 35, this enabling the rest to be brought as close as may be required to the work, and at the same time giving ample room for working the handle. The squared portion on the left end of the screw is useful when the slide is set round for obtuse tapers or at right angles for surfacing, as then the handle can readily be used on the end most convenient as regards position to the operator. This slide-rest (Fig. 35) has many good features, and is the production of Henry Milne, of Bradford. The slide-rest shown by Fig. 34 has most of the faults previously mentioned, namely, the unprotected screws in the slots of slides, the poor design of tool-holder, and inability to swivel the top slide completely round. The rest shown by Fig. 33 is the most usual pattern for metal-turning on the plain lathe without screw cutting; the type of universal tool-holder that swivels and clamps in any position is good, the screws work in slots, and these are open at the bottom to allow chips and dirt to pass clear out. The moving part of the bottom slide is also of full length, thus protecting both screw and slide from dirt and chips.

Figs. 33 to 35.—Three Types of Slide rests

Fig. 33

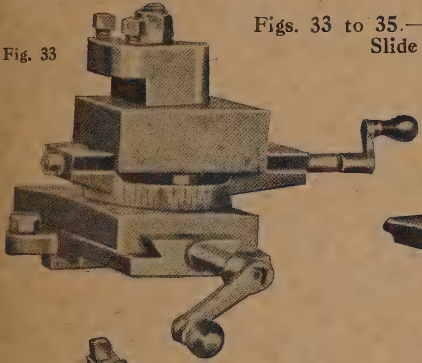


Fig. 35

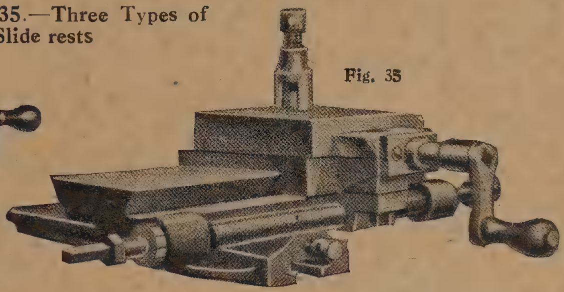
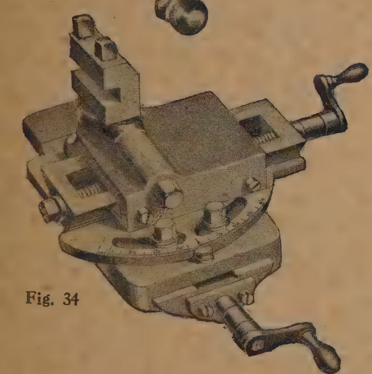


Fig. 34



Treatment of New Slide-rest.—The owner of a new slide-rest should first clean off any grit and accumulation of dry oil upon it with a soft rag soaked in paraffin or petrol, and should then wipe dry and apply machine oil to all parts, working the slides from end to end, and noting if the moving parts appear of the same degree of tightness in fit the complete length of travel. Also, he should inspect the screws that hold the adjusting strips (see Fig. 36), and try them with a screwdriver to see that screw A is jammed hard up; the screw B is for adjusting the strip and keeping it from easing back. It should be noted that the holes for the screws A are elongated to allow for lateral movement when adjustments are required. It is important that the sliding

parts be clean and periodically examined for adjustment and always kept in working order. No slackness of fit should be permitted, as this will cause irregular work, vibration, and possible chattering of the tool, but at the same time the opposite extreme of adjusting too tightly

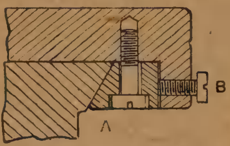


Fig. 36.—Adjusting V-strip of Slide-rest

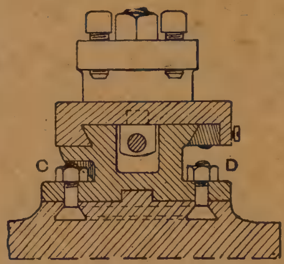


Fig. 38.—Cross Section Showing V-bolts for Swivelling

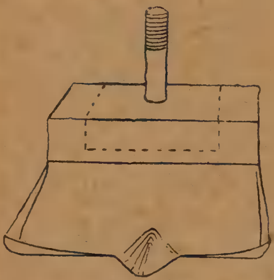


Fig. 37.—Shield Over Central Stud of Tool-holder

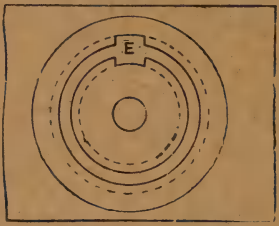


Fig. 39.—Method of Entering V-bolts in Groove

should be avoided. After using soap-water for turning wrought-iron and steel, all chips and moisture should be wiped off, and the surfaces oiled over to prevent corrosion. The practice of fitting a tin shield over the central stud of a universal tool-holder, as shown in Fig. 37 is a good one, and will save the metal chips and water from entering the slides. Sometimes a piece of American cloth is used for the same purpose. The soft-soap water may be caught in a tray underneath, strained and used again.

The swivelling of the upper or longitudinal slide for taper turning is effected by unscrewing the two nuts C and D (Fig. 38) of the V-headed clamping bolts, the heads of which engage in the annular V-groove formed in the surfacing slide below. To remove these bolts at any time, the annular groove has an aperture E (Fig. 39) cut the same size as the head of the bolt.

Milling, etc., with the Slide-rest.—The slide-rest can be made to carry appliances for milling, slotting, drilling, wheel-cutting, and grinding. These appliances are sometimes fixed in the tool-holder, but occasionally the top slide is removed and the apparatus secured to an angle plate bolted to the surfacing or lower slide. One of the most useful adjuncts to the slide-rest is the universal drilling frame, by means of which drilling, keyway, slotting, etc., may be done. The above appliances require, however, the attachment of overhead pulleys for their successful operation, although in the Drummond 4-in. lathe milling operations are performed by an ingenious arrangement whereby the saddle is made to swivel thus dispensing with the necessity for overhead gear.

Repairing Table Knives and Forks

The tools and implements used in cutlery grinding and repairing have already been illustrated.

Removing Handles.—To remove the handles from table knives, etc., immerse the handles in boiling water until the resin is melted (if pinned, first knock the pin out), and then pull the handles off. This applies almost alone to ivory, bone, and stag handles, as some of the xylonite handles have serrated tangs and will not come off, while most xylonite and self-tip handles will warp when subjected to heat.

The best way to separate handles from broken blades is to hold the broken blade in a gas jet or fire and let the heat gradually run up the blade until the resin melts sufficiently to allow the handle to be taken off. Xylonite handles must not be held close to the flame, as they are highly inflammable; but when a new xylonite handle is required, usually the old one is burnt off, while a bone or ivory handle can easily be split off by a stroke with the hammer.

Refixing Old Handles.—In refixing an old handle that has become loose, or in fastening on a new one, first fit the handle to see if it is straight; if not, remove the blade and bend the tang in the required direction. See that the handle fits properly before finally fixing. If the handle is to be pinned on, proceed as follows: Obtain a drill long enough to go right through. Grip the handle in the vice, with the blade upwards, and proceed to drill through, holding the blade in position with the left hand. Or mark the thin end of the tang where the hole should be, then drill it and see that the hole corresponds with the hole in the old handle (this applies chiefly to re-blading old ivory-handle knives) by passing a piece of wire through it. Pour melted resin into the hole in the handle, and having at the same time heated the tang, insert it and press it into position, holding it there until the resin sets. Now make a piece of wire red-hot and pass it through the pin-hole to clear it, and then secure the tang in the handle with a bit of brass or german silver wire. New handles can be procured from the manufacturers already finished for fixing on the blades, and new blades only require the tangs to be ground or filed to fit the handles should they prove too large.

Re-tanging Old Knife Blades.—One method of replacing the broken tang of a table knife is as follows: If there is sufficient of the old tang left, hammer the end flat, and about $\frac{1}{2}$ in. from the end set in a shoulder with the file and then file level, as in the section A (Fig. 1). Next procure a piece of thick iron wire, or cut off an old tang from a broken blade, and file in the same way to fit. Drill two holes through the tang, place it and the wire in the vice, and drill one hole through. Rivet them together

before drilling the second hole through. When both holes are riveted, file the edges level, and fit in the handle. The completed joint is shown in Fig. 1.

If the tang is broken off too close to

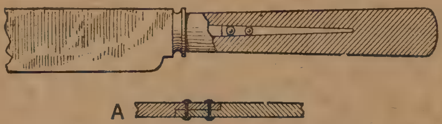


Fig. 1.—New Tang Riveted on

the bolster for the above method to be adopted, the repair must be effected as shown in Fig. 2. File the end level centre it with a punch, and drill a hole as deep and large as the bolster and tang will allow. To make a firm job, tap the hole; then, having cut a corresponding thread on the end of the new tang, screw in tight, and fit the handle on in the usual way.

Grinding.—The grinding of carvers, table knives, etc., will now be considered. If worn very much and thin at the point, cut the thinnest part away and proceed to grind the point to its original shape; straighten the edge, and then grind evenly, by a slightly rolling motion, to a thin edge. The glazer or buff for polishing the blades after grinding has a leather head or covering made of softer leather than that used for glazers for spring-knife blades, which are flat or slightly hollow, and have to be glazed on much harder surfaces. The table-knife blade, on the contrary, is rolled from the

Fig. 2.—New Tang Screwed on

back to the edge as a rule. The blades are whetted in much the same way as spring-knife blades, except that the whetstone (usually a long piece of bluestone) is dry; or they may be whetted by drawing lightly across a fine-grained emery stone.

When straightening the edges of the blades, it is much the better plan to keep the edge away from the body in the direction the stone is running (especially razors), and change from one hand to the other as required.

Inserting New Guard in Carving Fork.—To put a new guard and spring in a carving fork, first punch out the old pin and clear the old spring and rust, etc. out of the slot in the shank. Fit a new spring, and, placing the guard in the slot, screw up in the vice so that the holes in the shank and guard correspond. Knock in a new pin; but before riveting up, see

Fig. 3.—Broken Knife Blade

Fig. 4.—Blade Shaped and Drilled

Fig. 5.—New Handle on Old Blade

that the guard and spring fit and work properly. If the fork is to be cleaned, this should be done before the guard is fixed in; only the heads of the rivet will require glazing afterwards. Guards and springs can be bought ready for fixing, at prices varying according to pattern and quality.

Utilising Broken Carving Knife.—Sometimes the handle of a carving knife gets broken off at the point where the tang joins the blade, as at A (Fig. 3). Such a break cannot easily be repaired, and the parts are generally thrown away. Figs. 4 and 5 show how a handy knife may be made with such a broken blade. The part B (Fig. 4) nearest the handle

must be softened by heating it red hot, and cooling it slowly by burying in ashes. Care must be taken not to let the other part of the blade get heated. The stump of the tang should be filed off, the width of the blade reduced, and two holes bored through for fastening on the new handle. Two pieces of ebony or other hardwood $\frac{1}{8}$-in. thick are then fitted, one on each side, and fastened with brass wire rivets passing through the holes. The new handle is shaped as shown in Fig. 5, and rubbed down with fine glasspaper. A little polish will complete the job.

An Easily-made Hot-water Towel Rail

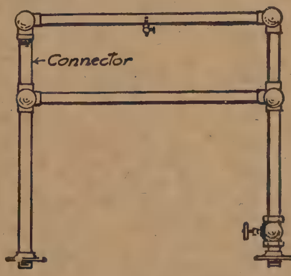
THE hot-water towel rail or towel airer as usually fitted is a high-priced article, not within the reach of those occupying property of moderate rental, owing to it being made of copper or brass tube, with brazed joints, special brass or gunmetal fittings, and nickel-plated finish. Were it not for the expense, the rail would be much more largely used, inasmuch as it is a source of considerable convenience and comfort.

The rail here illustrated is made up of iron tube and parts (the valve, if one is required, is of brass), and what makes the iron tube possible is the fact that globular fittings can be obtained to use with it, a kind of fitting of which little is generally known. Ordinary tube fittings would give a very unsightly appearance.

The fittings with globe-shaped bodies are made for railing work, being of malleable iron and obtainable from the warehouses which stock malleable-iron hot-water and gas fittings. Although designed simply for making up wrought-tube handrails, they have proved water-tight, and their shape and finish are sufficiently good to produce a presentable article for bath-room use.

It will be seen that the whole can be assembled without introducing more than one "connector" (a tube screwed for some distance at both ends for convenience in coupling up between two fixed points); a connector requires a backnut and this latter is best made by cutting a short section of a socket. This will be equivalent to a ring backnut instead of the hexagon kind, which would not look at all well. The ring backnut, if it comes where shown, will be quite inconspicuous. At the bottom of each leg a flange can be used as a foot, but the flange must have its thread tapped through to admit of this, as shown.

The air vent can be an air-cock of any ordinary kind, screwed into either of the top elbows or into the upper tube. The best plan is to screw it into the under-side of the upper tube, and have a short piece of small pipe extend up inside the tube as shown, so as to draw the air from the top of the tube.



A Hot-water Towel Rail

Finally, as to finish, two coats of dead white paint, each one rubbed down, and followed by one of enamel, will give the rail a good appearance. But there is one detail as to which there may be a difference of opinion; this is whether the pipe threads should be left visible. If care is used in screwing the pipe ends, but very little thread should show, and, if thought necessary, a little ordinary putty should suffice here, but with the connector thread there will be quite $1\frac{1}{2}$ in. in sight. For this, fill up the threads with soft solder and file smooth.

Camera Making

In this chapter will first be described how to make a quarter-plate folding hand or stand camera of a simple type, yet containing all necessary modern movements and adjustments. Afterwards the making of a reflex camera will be fully explained.

A QUARTER-PLATE FOLDING HAND OR STAND CAMERA

Figs. 1 and 2 show the camera open and closed respectively; Fig. 3 is a side elevation, Fig. 4 a plan, Fig. 5 a front elevation, and Fig. 6 an end elevation with the reversing back removed. The camera is made of planed-up $\frac{1}{4}$-in. mahogany throughout, except where otherwise indicated. Honduras or Mexican mahogany is best; the straighter the grain the better; and care should be taken that it is thoroughly well-seasoned and dry. In default of the foregoing, good quality fretwood may be used.

In Fig. 1, A is the camera body; B the hinged baseboard; C the extension board; D a brass plate, along which slides the frame carrying the front posts E, clamped in any position by the screw F; G the rising, falling, and swing front, secured by milled-head screws working in slotted brass plates on the front posts; H the brass flange for the lens; I the milled-head screw actuating the focusing pinion; J one of two clamping screws working in slotted struts K, which support the baseboard; L one of a pair of bent springs that cause the camera to open when the spring catch M is pressed; N a plumb level; and O a leather handle for carrying. In the plan (Fig. 4) will be noticed the finder A and the focusing scale B.

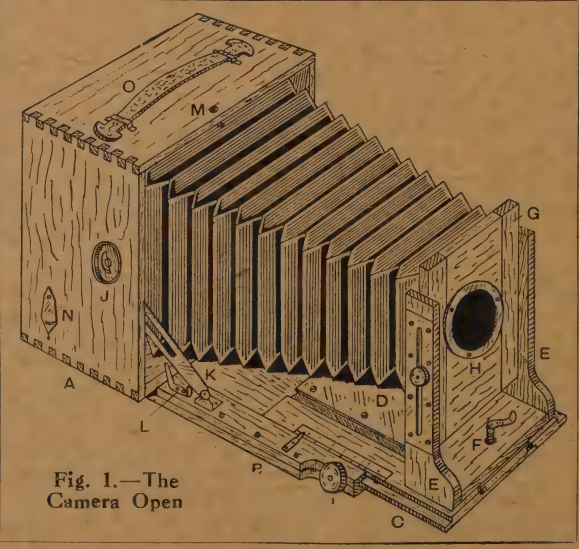


Fig. 1.—The Camera Open

The Body.—The camera body (Fig. 7) is 6 in. square and $3\frac{1}{2}$ in. deep. For this will be required four pieces 6 in. by $3\frac{1}{2}$ in. Well-fitting box pin joints are cut carefully on the eight ends, and these are put together with good, strong glue applied thinly. Before doing this, however, two saw-

Fig. 2.—The Camera Closed

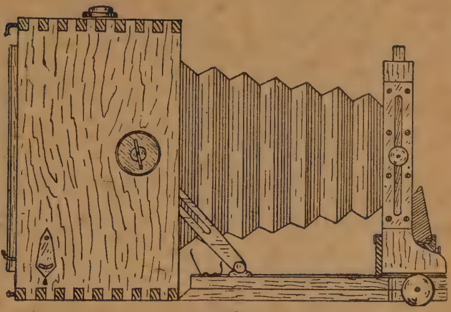


Fig. 3

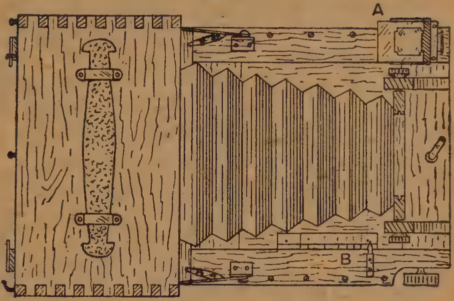


Fig. 4

Figs. 3 and 4.—Elevation and Plan of Camera

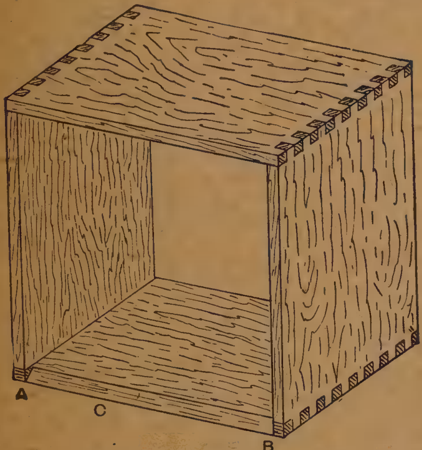


Fig. 7.—Body of Camera

Fig. 9.—Keyed Corner of Bellows Frame

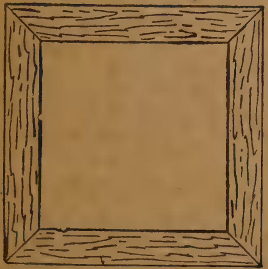


Fig. 8.—Bellows Frame

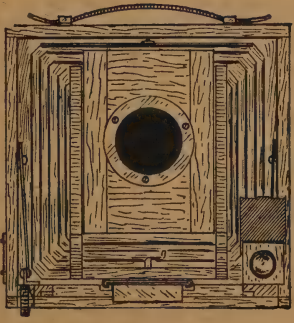


Fig. 5

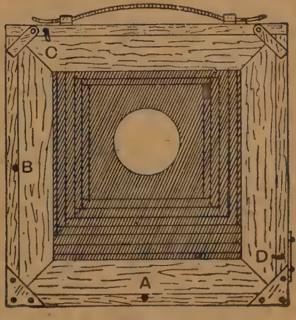


Fig. 6

Figs. 5 and 6.—Front and Back Elevations of Camera (Reversing Back Removed)

cuts should be made in one of the pieces, as at A and B, and the edge bevelled to an angle of 45° as shown at C, to allow the baseboard to fold up flush.

Bellows Frame.—This (see Fig. 8) is $5\frac{1}{2}$ in. square outside, and is made from four pieces $\frac{3}{4}$ in. wide mitred at the corners. The opening is 4 in. square. The frame having been glued up and allowed to set, diagonal saw-cuts are made at the four corners, as at A (Fig. 9), to take pieces of hardwood veneer, which are glued and wedged tightly in. When the glue has set, the projecting ends of the veneer are planed off. This operation is known as keying. The inner side of the bellows frame may with advantage be roughened, as this will give a better hold for gluing on the bellows. The frame is glued inside the body $\frac{1}{4}$ in. from the back edge, as seen in Fig. 6.

Reversing Back.—This, shown in elevation by Fig. 10 and in section by Fig. 11, is $5\frac{1}{2}$ in. square, with a central rectangular opening 4 in. by 3 in. It may be put together with mortise and tenon joints, or it may be mitred and keyed. Strips $4\frac{3}{4}$ in. by $\frac{1}{2}$ in. and $\frac{1}{8}$ in. thick are glued at the two longer sides of the opening, as at A and B (Fig. 11), leaving a 4-in. space between them. Over the strips are screwed brass plates C and D, $4\frac{3}{4}$ in. by $\frac{5}{8}$ in. and $\frac{1}{16}$ in. thick. These will project inwards for $\frac{1}{8}$ in. as shown, and serve to engage grooves on the dark-slide. Since an exact fit is necessary, it will be best to defer fixing the wooden strips and brass plates until the slides are made. Above the two narrow sides of the opening are glued $\frac{3}{8}$-in. strips of black velvet, as indicated by the dotted lines in Fig. 10, to prevent light getting between the dark-slide and the reversing back. Small triangular recesses A, B, C, and D, $\frac{1}{16}$ in. deep, are chiselled at each corner to fit the brass corner plates and the turn-catches that hold the reversing back in position. These plates and catches are $1\frac{1}{16}$ in. thick, and are fixed flush in the camera back, as seen in Fig. 6.

Baseboard.—The baseboard (Fig. 12) is $5\frac{3}{4}$ in. by $5\frac{1}{2}$ in. One of the shorter ends is bevelled to an angle of 45°, so that it will hinge flush with the body. Two rails A and B, to engage the extension board, are next prepared; these are $5\frac{1}{2}$ in. by $\frac{3}{4}$ in., and have a rebate cut along their length $\frac{1}{4}$ in. wide and $\frac{1}{10}$ in. deep, as shown in section (not to scale) at A (Fig. 13). The rails are fixed to the baseboard with brass screws; but before doing this the extension board should be prepared, and recesses cut for the rack and pinion, as will be presently explained. A piece $1\frac{1}{4}$ in. by $\frac{3}{8}$ in., curving at one end as at C (Fig. 12), is cut out in the baseboard and one of the rails, for the milled-head screw of the pinion.

Extension Board.—Fig. 14 is a plan and Fig. 15 a section of the extension board, which is $5\frac{1}{2}$ in. by $4\frac{1}{2}$ in., and should preferably be made in three pieces cramped and keyed together, with the grain crossing, to prevent warping. The two longer sides are rebated to a width of $\frac{1}{4}$ in. and to a depth to fit the baseboard rails and allow free but not too loose movement. The centre having been marked, as shown by the dotted line in Fig. 14, lines are set out for two longitudinal grooves A and B, which are $\frac{1}{4}$ in. wide by $\frac{1}{8}$ in. deep and $1\frac{1}{2}$ in. distant from each other, measuring from their inner edges. The purpose of these grooves will be explained later.

Focusing-screen Frame.—This (see Fig. 16) measures $5\frac{3}{8}$ in. by 4 in. outside, the opening being 4 in. by 3 in. It is mitred and keyed, the required section for the four sides being as shown in Fig. 17. The rebate for the ground glass is $\frac{1}{10}$ in. wide and $\frac{1}{8}$ in. deep. The glass is secured in the frame by brass strips (Fig. 18) screwed across at the corners, as at A in Fig. 16. Grooves are cut in the two longer sides to fit the brass plates on the reversing back.

Rising-front Posts.—These two posts (Fig. 19) are $4\frac{5}{8}$ in. long, $1\frac{3}{8}$ in. wide at the widest part, and $\frac{5}{8}$ in. wide at the narrowest part. Two slotted brass plates (Fig. 20) are required for the front posts; these should be let in flush, cutting away sufficient wood. Before screwing them on, mark the outlines of the slots on the posts by drawing a pencil round inside

Fig. 10

Fig. 11

Figs. 10 and 11.—Reversing Back

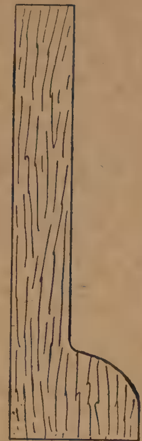


Fig. 19.—Rising-front Post

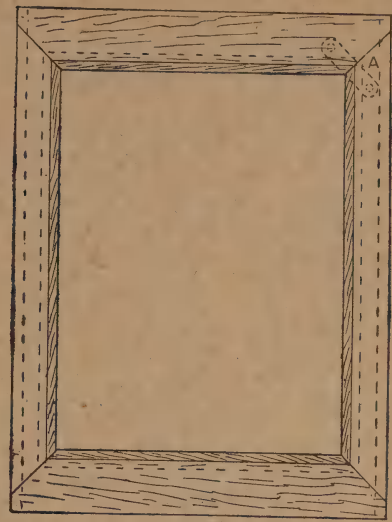


Fig. 16

Fig. 17

Figs. 16 and 17.—Focusing-screen Frame

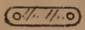


Fig. 18.—Brass Corner Strip

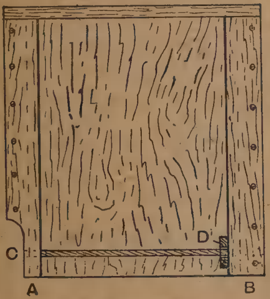


Fig. 12

Fig. 13

Figs. 12 and 13.—Baseboard and Rails

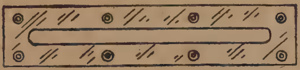


Fig. 20.—Slotted Plate for Front Post

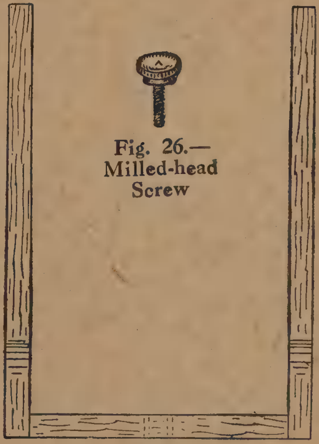


Fig. 21

Fig. 26.—Milled-head Screw

Fig. 14

Fig. 15

Figs. 14 and 15.—Extension Board

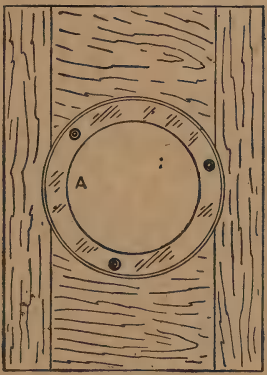


Fig. 24

Fig. 25

Figs. 24 and 25.—Rising-front Board

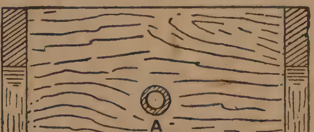


Fig. 22

Figs. 21 and 22.—Front Post Frame

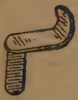


Fig. 23.—Clamping Screw

the slotted plates, and, with a fretsaw, cut the wood to correspond, afterwards well smoothing with a file.

The two posts are screwed to a rectangular cross-piece, $2\frac{3}{4}$ in. by $1\frac{3}{8}$ in., as shown in elevation by Fig. 21 and in plan by Fig. 22. A hole is bored in the cross-piece about $\frac{3}{8}$ in. from the front, as at A (Fig. 22), to take the screw-bush for the clamping screw. The latter is of the shape shown by Fig. 23, with the screw portion about $\frac{3}{16}$ in. in diameter and $\frac{1}{2}$ in. long.

Brass Fittings.—It may here be mentioned that most of the brass fittings can be purchased, a few firms making a speciality of such goods. It is advised that those requiring accurate lathework, such as the pinion, milled-head screws, and similar parts, to which may be added the rack, should be bought, as they will hardly repay the trouble of making unless the maker is a skilled metal-turner. All the flat parts, however, may be made if desired from No. 16 gauge sheet brass, finished and lacquered. Where bending is necessary, the brass should first be annealed—that is, made red hot and plunged into cold water.

Rising, Falling, and Swing Front.—This front is also the lens board (see Fig. 24), and measures $3\frac{7}{8}$ in. by $2\frac{11}{16}$ in. It should be made in three pieces clamped together with the grain crossing, as shown in section by Fig. 25. The centre of the two longer sides having been found, holes are drilled for brass screw bushes, to take the small brass milled-head screws (Fig. 26), which clamp the front in any position. The centre of the front is found by drawing diagonals, and a circle of sufficient diameter to take the brass lens flange A (Fig. 24) is marked, and cut with a fretsaw. Thin metal or rubber washers are inserted between the posts and the rising front, and also against the shoulders of the milled-head screws.

Guide Plates.—The brass guide plates on which the front-post frame slides are $1\frac{3}{4}$ in. wide. The longer one (Fig. 27) is $5\frac{5}{8}$ in. long; $\frac{1}{10}$ in. is cut away from each side for $\frac{3}{8}$ in. from one end, as at A and B, and the narrowed portion is bent over at a right angle, as indicated by the dotted line, serving as a front stop for the extension board. Ten countersunk holes are drilled for screws, and a slot is cut at C to engage the spring catch that fastens the camera when closed. The shorter guide plate (Fig. 28) is $2\frac{3}{8}$ in. long, and is drilled with four countersunk screw-holes. The longer plate is screwed lengthwise in the centre of the extension board, and the shorter one is fixed in line with it inside the camera body against the bellows frame, having first had screwed on a piece of $\frac{1}{4}$-in. wood $2\frac{3}{8}$ in. by $1\frac{1}{2}$ in. to raise the plate to the level of the longer one.

Sliding Plate.—The brass sliding plate (Fig. 29), $\frac{1}{32}$ in. thick, is screwed to the bottom of the front-post frame. It measures $2\frac{1}{8}$ in. by $1\frac{3}{8}$ in., and is turned over at the two shorter ends sufficiently to slide with ease along the guide plates, this being permitted by the longitudinal grooves in the extension board. A rectangle, A, $\frac{7}{8}$ in. by $\frac{5}{8}$ in., is marked in the centre, and a narrow strip $\frac{1}{16}$ in. wide is cut away inside on three sides of the rectangle as indicated, so that the central portion remains as a tongue or spring, which serves to transmit the pressure of the clamping screw to the guide plates, while preventing the screw itself from scratching or denting them. Six holes are drilled for screws, and countersunk on the under-side.

Hinges.—Two brass hinges (Fig. 30) are required for attaching the baseboard to the body. These are fixed from the under-side, their places being marked with the baseboard laid against the camera body in the closed position, and the wood recessed so that they lie flat and will close flush. Before attaching the hinges, two small triangular pieces of wood (Fig. 31) are glued inside the top corners of the body, to act as stops and prevent any strain on the hinges by the weight of the baseboard bearing inwards when closed.

Spring Catch.—Fig. 32 shows the spring catch that fastens the camera. It is a bent brass spring A, $\frac{1}{32}$ in. thick,

having soldered to it a projecting push B, while at the end a notch C is made, and a small triangular piece bent up, which engages in the slot cut in the front end of the longer guide plate. Two holes are drilled for screws. The catch is fixed inside at the top of the camera body. The centre having been marked, a recess is cut so that it will lie flush, then the position of the push is ascertained, and a hole bored for it; this hole is bevelled round at the top, so that the push is accessible to pressure by the finger while not actually projecting.

Struts.—The two slotted struts are as shown by Fig. 33. They are 4 in. long and $\frac{3}{8}$ in. wide at the widest part. The slot is $\frac{1}{8}$ in. wide. About $\frac{1}{2}$ in. from one end a short tributary slot A is cut, at a right angle to the main slot. An angle plate (Fig. 34) is riveted or attached by a short bolt and nut to the narrower end of each strut.

Side Plates and Clamping Nuts.—The two side plates that carry the clamping nuts and bolts which work in the slotted struts are shown in plan and elevation by Figs. 35 and 36 respectively.

Fig. 27.—Brass Guide Plate

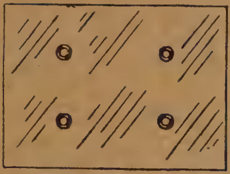


Fig. 28.—Brass Guide Plate

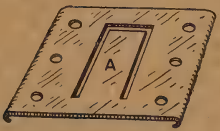


Fig. 29.—Brass Sliding Plate

Fig. 30.—Baseboard Hinge

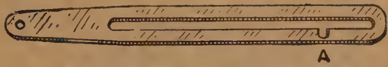


Fig. 33.—Slotted Strut

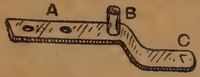


Fig. 32.—Spring Catch

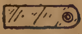


Fig. 46.—Turn-catch

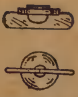
Figs. 35 and 36.—Side Plate

Fig. 42.—Side Spring

Fig. 31.—Stop Block

Fig. 45.—Corner Plate

Fig. 43.—Focusing Pinion



Figs. 37 and 38.—Clamping Nut

Fig. 44.—Rack

Fig. 40.—Flanged Nut

Fig. 34.—Angle Plate

Fig. 39.—Clamping-nut Bolt

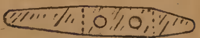


Fig. 41.—Side Spring, Before Bending

They each consist of a square brass plate, to which is soldered a circular ring $\frac{7}{8}$ in. in diameter and $\frac{1}{4}$ in. deep. The outer edges of the ring are rounded. Four holes for screws are drilled and countersunk on the back of the square plate, and in the centre a hole is drilled to admit the clamping bolt.

The two brass clamping nuts are as shown in plan and elevation by Figs. 37 and 38. They engage in small bolts (Fig. 39). It will be noted that part of the bolt shank is filed square to fit the slotted strut, so that it may not work loosely round when the nut is turned.

Fixing Struts and Side Plates.—The method by which the slotted struts and side plates are fixed will be understood by referring to Fig. 1 (p. 58). The camera body is stood upright, with the baseboard resting on the table or bench, and one of the struts, attached to an angle plate, is adjusted temporarily in what seems a suitable position by means of pins.

The position for the hole for the clamping bolt is next marked on the side of the camera; it should come against the short tributary slot in the strut, and will be found to be about $2\frac{7}{8}$ in. measured from the top outside, and about $\frac{7}{8}$ in. measured from the edge nearest the baseboard. With the mark as centre, a circle $\frac{7}{8}$ in. in diameter is described, to accommodate the ring on the side plate, and is cut out with a fretsaw. A square recess is cut inside, so that the plate itself will lie flush, and the latter is screwed on.

The clamping bolt is now inserted, passing it through the slotted strut, and the screw-nut is placed over the end of the bolt on the outside of the camera. Then, having seen that the baseboard is at a right angle, the places for the screws that secure the angle plate to the baseboard are marked with a bradawl. The angle plate should be taken a trifle inwards, so that the strut may just clear the inside of the body when closing. The strut will also require to be bent very slightly. The opposite side plate and strut are fixed in a similar manner, to correspond exactly with the others.

Flanged Nut for Tripod Screw.—The flanged nut for the tripod screw (Fig. 40) may next be fixed. A hole is bored in the centre of the body at the bottom, to take the nut portion, and a circular recess to accommodate the flange is cut outside. The flange is secured with three countersunk screws.

Side Springs.—The two brass side springs may be cut from $\frac{1}{32}$ in. sheet brass to the shape shown by Fig. 41, and bent as indicated by Fig. 42. They are screwed on the baseboard as shown in Fig. 1.

Rack and Pinion.—The pinion should be of the kind illustrated by Fig. 43, measuring $4\frac{1}{4}$ in. from the outside of the end plate A to the outside of the bridge plate or bearing B. A recess is cut for it in the baseboard, as seen at C in Fig. 12, and also a recess D to fit the bridge plate, so that it lies flush. The bridge plate having been screwed in, the milled head of the pinion is removed, the pinion passed through the hole between the baseboard and rail, and its opposite end inserted in the bridge plate. The end plate is then screwed to the edge of the baseboard and rail, a recess having been cut so that it will lie flush, and the milled head of the pinion is replaced. The pinion should be of as small diameter as possible, owing to the thinness of the baseboard.

The rack is of the flat-cut description shown by Fig. 44. Two will be required, each $4\frac{1}{4}$ in. long and $\frac{1}{4}$ in. wide. Recesses are cut for them along the bottom of the extension board, as indicated by the black portions A and B in Fig. 15.

Reversing-back Fittings.—The triangular corner plate and the turn-catch for securing the reversing back are shown by Figs. 45 and 46 respectively. The method of fixing these will be seen by reference to Fig. 6 (p. 59).

Polishing.—The whole of the camera may now be french-polished, except the back of the bellows frame, focusing-screen frame, reversing back, and rising-front board, which are blackened with a dull-black varnish. For this purpose, all brass fittings that are in the way should first be carefully unscrewed.

Conical Bellows.—The method of setting out and folding the conical bellows is shown by Fig. 47, and should be practised on stout paper, before starting on the leather.

through D the horizontal line G H, $2\frac{1}{2}$ in. long. Join E G and F H; this gives the shape for one side of the bellows. To set out the remaining sides at the correct

Fig. 48.—The Camera Bellows Complete

Fig. 52.—Brass Plate for Top of Finder

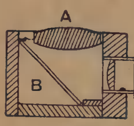


Fig. 49

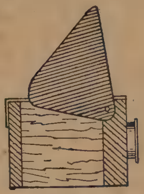


Fig. 50

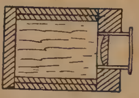


Fig. 51

Figs. 49 to 51.—Section and Side Elevation of Finder and Plan of Box

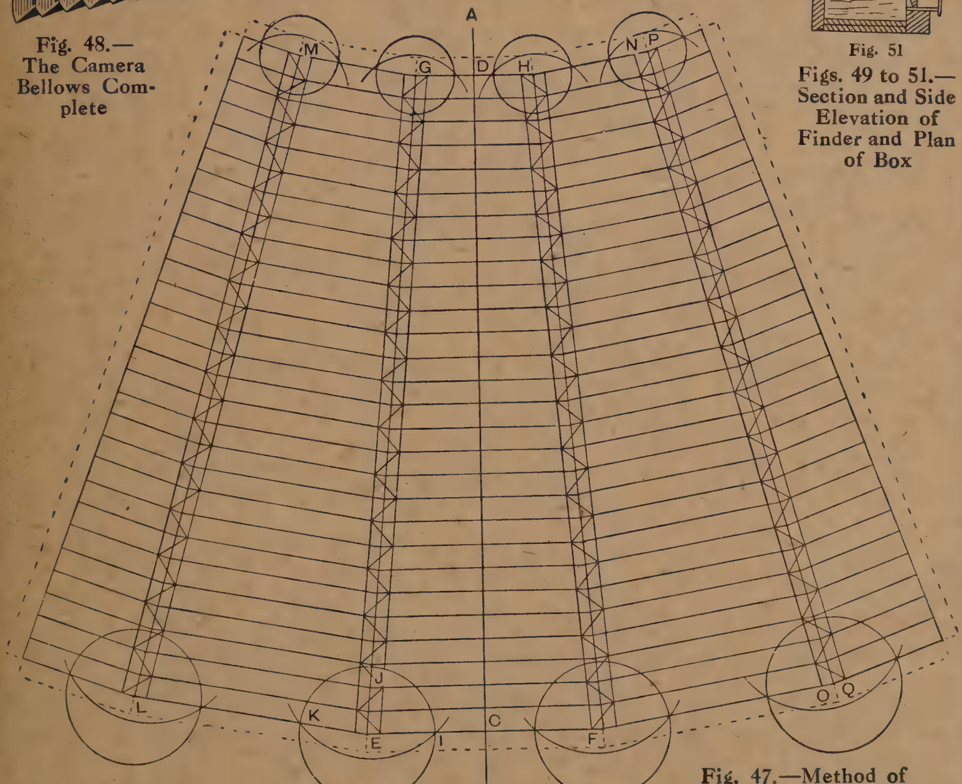
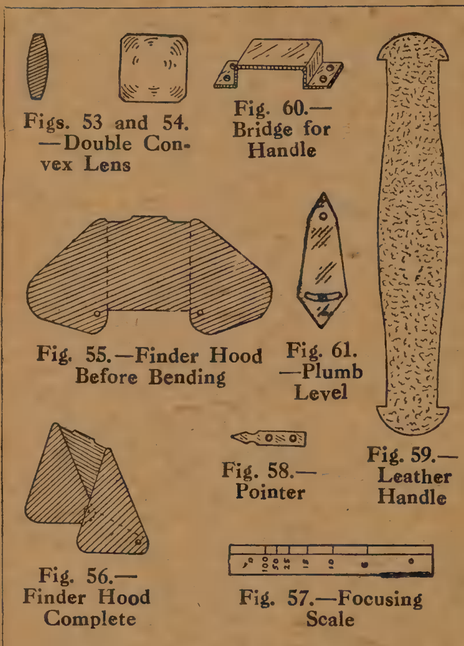


Fig. 47.—Method of Setting-out Bellows

First rule a perpendicular line, A B, in the centre of the material. From a point C on this line, near the bottom, measure off C D 1 ft. 2 in. long. Through C draw the horizontal line E F, 5 in. long, and

angles proceed as follows: With E as centre, and with any convenient radius, describe a circle cutting E F in I and E G in J. With J as centre, and J I as radius, describe an arc cutting the circle

in K. Join E K, which produced gives the angle for the side E L. Make E L 5 in. long, and obtain the angle for the side G M by means of a circle and arc, as before described; make G M $2\frac{1}{2}$ in. long and join M L. The opposite side is set out in a similar manner. The remaining side is divided into two for convenience of joining, as shown. Having set out the five divisions, rule lines parallel to the ends



Figs. 53 and 54.—Double Convex Lens

Fig. 60.—Bridge for Handle

Fig. 55.—Finder Hood Before Bending

Fig. 61.—Plumb Level

Fig. 58.—Pointer

Fig. 59.—Leather Handle

Fig. 56.—Finder Hood Complete

Fig. 57.—Focusing Scale

of each, $\frac{1}{2}$ in. apart, thus dividing each section into twenty-eight parts. Then draw the vertical parallels, one on each side of the vertical lines and $\frac{1}{4}$ in. distant from them, as at N O and P Q. In the irregular squares thus formed draw short diagonal lines from corner to corner, from right to left and from left to right alternately. Finally mark off $\frac{3}{8}$ in. all round for joining, as shown by the dotted lines.

To fold, crease all the horizontal lines, first one way and then the other, the narrower spaces going inwards. The inward lines should be ruled with a hard point to make them fold easily. The short diagonal lines are then creased, after which no great difficulty will be found in bending the four sides and obtaining the finished bellows, as shown by Fig. 48. The join is glued, and is placed next the bottom of the camera, where it will not show. The two ends of the bellows are glued to the bellows frame and the rising front respectively.

The best material for the bellows is black morocco leather lined with black lining, the two being glued together with a mixture of 4 parts of thin glue to 1 part of flour paste. Before gluing, damp the leather to render it limp. For marking, a chalk pencil is used, and care must be taken not to pierce the leather with the point of the compasses. The folding is done before the material is quite dry, and when the glued join has set, the bellows is placed flat under a weight for a time. When finished, the inside may, if at all shiny, be blackened with dull black varnish.

Brilliant Finder.—This (see Fig. 50) consists of a small mahogany box made as shown in side section by Fig. 49 and in plan by Fig. 51, the outside measurements being $1\frac{1}{4}$ in. long, $\frac{7}{8}$ in. wide, and $\frac{7}{8}$ in. deep. The bottom and three sides are $\frac{1}{8}$ in. thick, and the front $\frac{1}{4}$ in. thick. In the front a circular hole is bored to take a brass tube about $\frac{3}{8}$ in. long and $\frac{3}{8}$ in. in diameter. which holds a small plano-convex lens of 1-in. focus, kept in place by a couple of blackened split-wire rings. Grooves are cut in the two sides, at the top, to hold a double convex lens of 1-in. focus A (Fig. 49); this is shown in section by Fig. 53, and is cut square, as in Fig. 54, to fit the box. A small mirror B (Fig. 49) is inserted at an angle of 45°; it is secured by a thin strip of wood glued at the bottom, and by a short nail or screw against its top edge. The top of the finder is covered with a bent brass plate, cut as shown in Fig. 52, and bent at the dotted line; it is fastened with three screws. The size of the opening in the plate should correspond with the amount of view included by the camera lens. The hood is of bronzed sheet-iron, of the shape indicated by Fig. 55, and

bent at the dotted lines as in Fig. 56; it is secured with two small bronze pins or nails, and should open and close readily, but not too loosely. The finder is attached to the baseboard rail by a hinge at the bottom, so that it will fold inwards out of the way to allow closing. The hinge should be recessed in both finder and rail.

Focusing Scale.—As shown in Fig. 57, this consists of a narrow strip of ivory

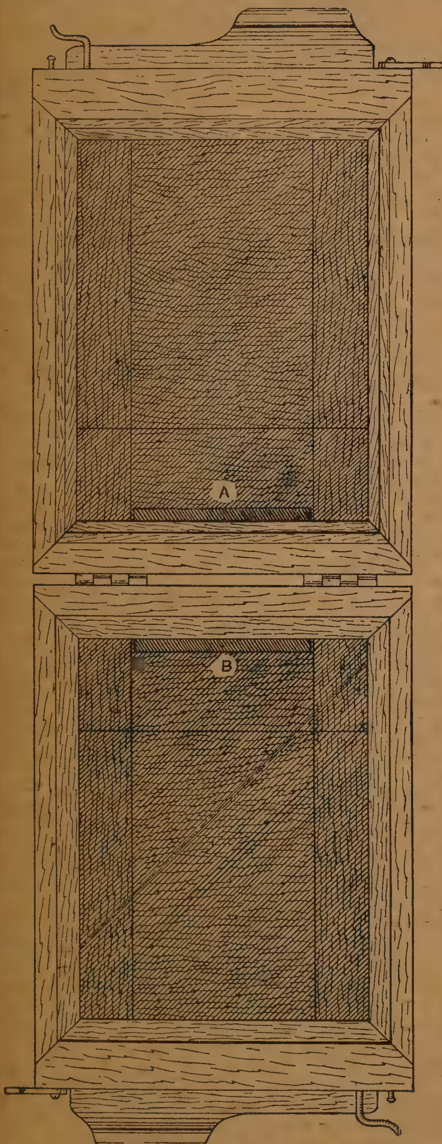


Fig. 62.—Double Dark-slide, Open

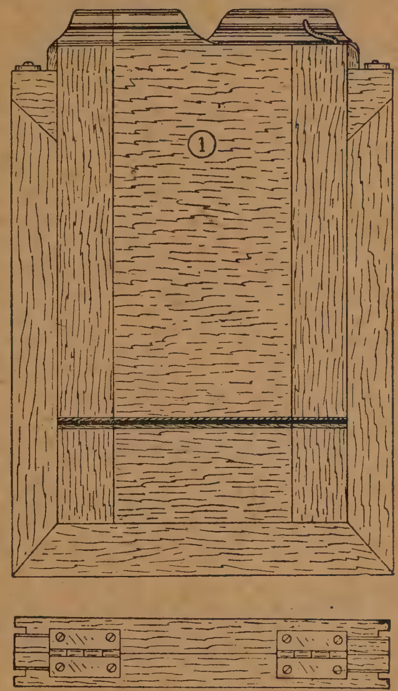


Fig. 63.—Two Views of Dark-slide, Closed


Fig. 64.—Saw-kerfs in Top Bar of Dark-slide

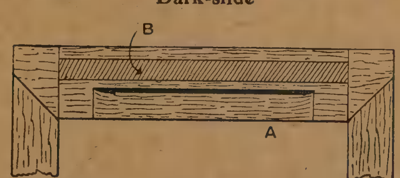


Fig. 64A.—Top Bar of Dark-slide Recessed for Shutter

marked to agree with the focus of the lens at different distances; the markings must be found by experiment. The pointer (Fig. 58) is of brass, and is screwed to the baseboard rail, as shown in Figs. 1 and 4 (pp. 58 and 59).

Handle, Level, etc.—The leather handle (Fig. 59) is attached to the top of the camera with brass bridges (Fig. 60). The plumb level (Fig. 61) is screwed to the side of the camera, so that it will swing loosely, a small screw being first inserted within the curved slot, to be central when the camera back is vertical. A blackened notch or mark is made on the wood against the lower point of the level to indicate the vertical position.

MAKING THE DARK-SLIDE

The dark-slide is undoubtedly more difficult to make than the camera, owing to the great neatness and exactness required in order to ensure perfect exclusion of light and a correct fit. The one now to be described is book-form and of the Lancaster pattern; it is shown open by Fig. 62 and closed by Fig. 63. To make the slide, a sufficient quantity of mahogany double grooving (Fig. 68) will be necessary. This can be made if preferred, but it will be better to purchase it. It is sold ready mitred to any desired lengths; 1 ft. 8 in. is required for a quarter-plate slide. To secure a better correspondence in size in the two halves of the slide it is usual to cut and plane them both together, preventing them from sticking when glued by rubbing the insides of the mitred corners with wax for an inch each way.

First cut the two frames so that the inner opening is of the correct size, paying no attention to the outside dimensions, as these can be brought right afterwards by planing. The opening should be 4 in. by 3 in., the innermost rebate, shown in the bottom half of Fig. 62, measuring $4\frac{1}{4}$ in. by $3\frac{1}{4}$ in. full. Having got the mitres right, the two halves are glued and cramped, or tied tightly round with string, and allowed to set thoroughly. When quite set, and on no account before, a diagonal saw-cut is made in the centre of each corner to take a thin strip of veneer, which is glued in. When the glue has set, the projecting pieces of veneer are planed level. Placing the two halves together, the next step is to mark the outside dimensions and to plane them down as required, taking off an equal amount on opposite sides. The thickness of the grooving may prove right for the top and bottom, but the sides must be reduced. The outside of the slide should measure $5\frac{5}{16}$ in. by 4 in.

The top bar of each half will now have to be cleared on the outside to admit the shutters. To do this, a series of saw-cuts are made, as shown by the dotted lines in Fig. 64, level with the bottom of the first rebate or groove. The intervening space is then carefully removed with a small chisel, and rendered flat with glasspaper and file. A recess about $2\frac{3}{8}$ in. long, $\frac{5}{16}$ in. wide, and $\frac{1}{16}$ in. deep is then gouged out, as at A (Fig. 64A), to engage the wooden strip on the shutter which prevents the latter pulling right out. About $\frac{1}{8}$ in. from the top a $\frac{1}{4}$-in. wide recess is cut to a depth of $\frac{1}{32}$ in., in which a strip of black velvet B is glued, to exclude light which might otherwise get between the shutter and slide. The shutter grooves must next be cut through the top bar, continuous with the grooves in the sides; this is done carefully with a small gouge and a narrow flat file.

Dark-slide Shutters. — The two shutters can now be proceeded with. These consist of three strips keyed together with thin pieces of veneer, as shown by Fig. 65. The central piece is $1\frac{7}{8}$ in. wide, and the side pieces may be $\frac{3}{4}$ in. wide. After joining up, the shutter is planed carefully to measure $5\frac{1}{2}$ in. long, $3\frac{1}{4}$ in. wide, and $\frac{1}{6}$ in. thick. A rebate is cut on three sides to fit the grooving of the slide; this will require to be about $\frac{1}{10}$ in. wide and $\frac{1}{16}$ in. deep. The shutter is next cut horizontally across, $1\frac{3}{16}$ in. from the bottom, for the hinge, and the two edges of the cut are bevelled to an angle of 45°, as shown in enlarged section by Fig. 66. A rebate $\frac{1}{2}$ in. wide and $\frac{1}{32}$ in. deep is then cut to accommodate a thin strip of black leather A; this is glued on,

the leather being first examined closely to see that there are no minute holes in it.

The top of the shutter is now shaped to form a finger-piece, as seen in the various illustrations, and rounded with the gouge to the section indicated in Fig. 67. Before doing this, a strip of wood A, about $\frac{1}{12}$ in. thick, is glued across the top of the shutter at such a height that it will rest on the top bar of the slide when the shutter

the bottom end, as shown in Fig. 63, care being taken that they are placed horizontal and level. Two brass hook catches (Fig. 69) and two short round-headed brass nails are required as fastenings.

The catches are fixed with round-headed brass screws, as seen in Fig. 62, so as to move rather stiffly. The correct position for the nails having been marked, holes are started with a drill or awl before

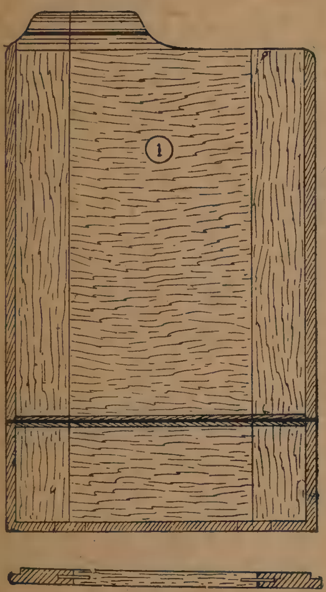


Fig. 65.—Shutter of Dark-slide

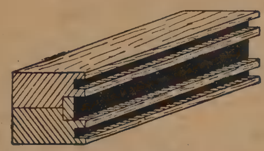


Fig. 68.—Double-grooving of Dark-slide

Fig. 66.—Hingeing the Shutter

Fig. 69.—Hook Catch

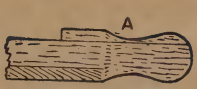


Fig. 67.—Finger-piece of Shutter

Fig. 70.—Bent-wire Catch

is closed, and form a shoulder. The strip is gouged and shaped to match the other side of the shutter. A small circular recess is cut on the outside of each shutter near the top, to take an ivory number, which is glued in.

The inner sides of the shutter are coated with a dull black varnish, and when this is dry the shutters are tried in the slides. If they are a good fit, easy but not loose, the thin strips of wood A and B (Fig. 62), which prevent their complete withdrawal, may be glued on.

The brass hinges are now screwed on

inserting them, to avoid splitting the wood; they should be cautiously driven in with a wooden mallet.

Two bent brass-wire screw catches (Fig. 70) are inserted, as shown in Fig. 62, to prevent the shutter being accidentally pullled out when not desired.

The outside grooves to engage the brass plates on the reversing back should now be marked very carefully on the two side edges, as shown in Fig. 68. These are $\frac{1}{12}$ in. wide and $\frac{1}{8}$ in. deep. The exact position for them should be found by reference to the reversing back itself

and also by comparison with the focusing-screen.

Two round-headed screws are inserted at the back of the camera body, and made to project $\frac{1}{8}$ in. to act as stops for the slide, as shown at A and B in Fig. 6 on an earlier page. A couple of bent-wire catches similar to those used on the slide are screwed at the camera back, as at C and D (Fig. 6); these are turned over the top of the slide to prevent it slipping while the shutter is being withdrawn.

A metal separator is unnecessary in a quarter-plate slide; a piece of thick black cardboard, $4\frac{1}{4}$ in. by $3\frac{1}{4}$ in., placed between the two plates, answers all requirements.

In conclusion, the slide is french-polished to match the camera, and the wooden box of the finder having also been french-polished, it is hinged to the baseboard. The apparatus should be rested in every possible position to see that the fittings work properly, and careful search should be made for any entrance of light. One or two plates are then exposed and developed to test whether the slide is quite light-proof.

MAKING A QUARTER-PLATE REFLEX CAMERA

There will now be given instructions on making a simple quarter-plate reflex camera suitable for use with a Bausch and Lomb shutter shown fitted in Figs. 71 and 72, and obtainable from photographic dealers, or with a focal plane shutter, the construction of which will be dealt with.

Fig. 71 is a side elevation of the complete apparatus, which is made of $\frac{1}{8}$-in. mahogany, except where otherwise stated. The rubber tube A operating the pneumatic release of the shutter B is carried through the side of the camera, in order to make connection with the mirror mechanism. The finger-piece C actuates the mirror release. At the top of the camera is a folding hood D, to screen the ground glass from extraneous light; the frame E carrying the hood is hinged, and lifts up, to render the ground glass accessible for cleaning. The focusing pinion is at F, on the same side as the mirror release; but, if preferred, it may be placed on the opposite side. At G is a plumb-level. The reversing back H may be made to take any standard pattern of double dark-slide; that shown is designed for those which have grooves down the sides, as in the Lancaster type. Fig. 72 is a front elevation.

The sectional elevation (Fig. 73) will give a good idea of the internal arrangements. The outer body should first be made, beginning with the bottom A and two sides, which may be fitted together with small brass screws. The bottom is 8 in. by 6 in., and the sides 8 in. by $6\frac{3}{8}$ in. The top B is 8 in. by $5\frac{1}{2}$ in., and has an opening cut in it $4\frac{1}{4}$ in. square, starting 1 in. distant from the back end. This opening is rebated for a width and depth of $\frac{1}{8}$ in. all round, to take the ground glass. The strip C is $5\frac{1}{2}$ in. by $\frac{3}{4}$ in., and is glued to the bottom.

The Frame.—The frame D, against which rests the reversing back, may next be made; this is $5\frac{7}{8}$ in. by $5\frac{1}{2}$ in., with an opening $4\frac{1}{4}$ in. square, equidistant from three of its sides. The strip E, $5\frac{1}{2}$ in. by $\frac{3}{8}$ in., is screwed to the top of this frame, and the latter is then fixed $\frac{3}{16}$ in. distant from the back, as shown, by means of glue and small screws. The piece F, $5\frac{1}{2}$ in. square, is now fastened in; it rests at one end on the strip C, and is thus raised $\frac{1}{4}$ in. from the bottom, to serve as a guide for the focusing extension G. A strip $\frac{1}{4}$ in. wide is glued at each side, as shown at A and B in Fig. 72.

Before proceeding with the focusing extension, the frame H (Fig. 73) is made; this is $5\frac{7}{8}$ in. by $5\frac{1}{2}$ in., and has an opening 3 in. square, which starts $1\frac{3}{8}$ in. from the bottom of the frame and is bevelled at the edges.

The Focusing Extension. — This consists of a board $6\frac{1}{2}$ in. by 5 in., and $\frac{3}{16}$ in. thick; it should preferably be made in three pieces keyed together, to prevent warping. The rack (Fig. 74) is fixed lengthwise down the centre; if it projects too much, so as to interfere with free movement, a recess should be cut for it. The pinion is shown by

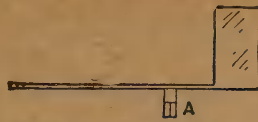


Fig. 83.—Plan of Lower Lever

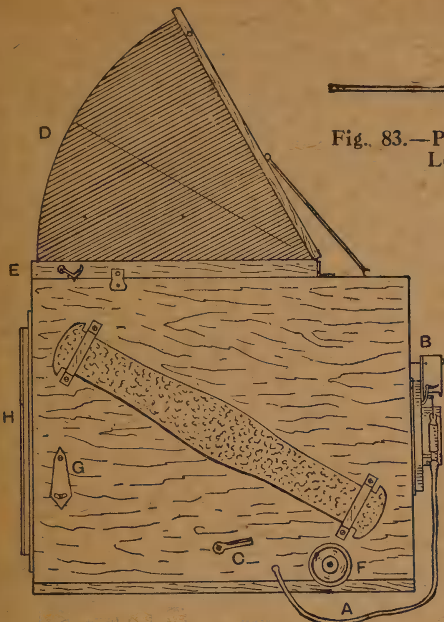


Fig. 71.—Side Elevation of Reflex Camera

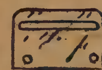


Fig. 78.—Slotted Front Plate

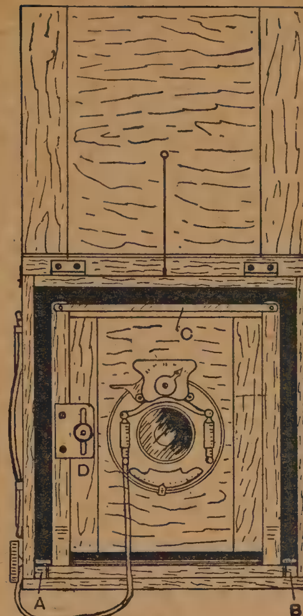


Fig. 72.—Front Elevation of Reflex Camera

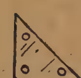


Fig. 80.—Corner Plate

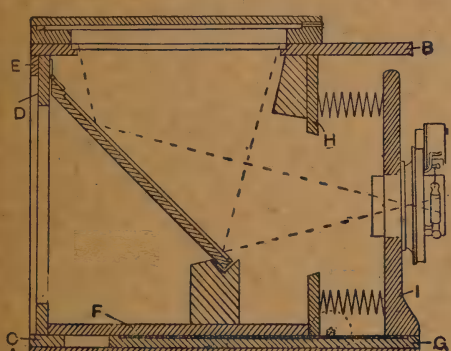


Fig. 73.—Sectional Elevation of Reflex Camera

Fig. 81.—Turn Catch

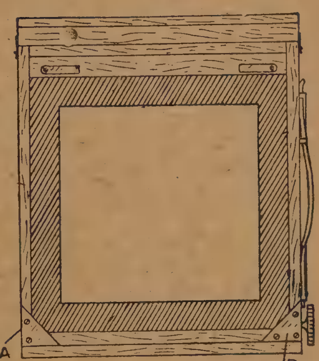


Fig. 79.—End Elevation of Camera, with Reversing Back Removed

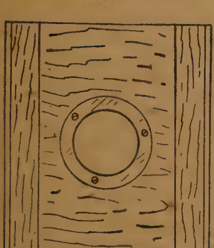


Fig. 77.—Elevation of Rising Front

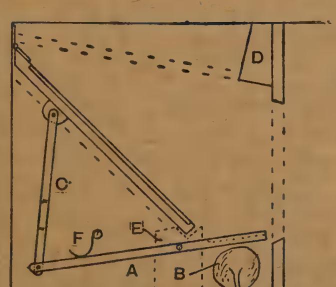


Fig. 82.—Details of Mirror Release

Fig. 74.—Rack

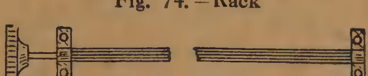


Fig. 75.—Pinion

Fig. 76.—Section of Rising Front and Posts

Fig. 75; the position for this is indicated in Figs. 71 to 73. It is attached by screws to the side strips A and B (Fig. 72).

The Rising Front Posts.—These are of the section shown at I (Fig. 73), $5\frac{5}{8}$ in. long and $\frac{3}{8}$ in. thick. A groove is cut down the centre of each for the rising front to slide in, as shown in section by Fig. 76. The rising front board (Fig. 77) is 5 in. by $4\frac{3}{8}$ in., and consists of three pieces keyed together. The two sides are rebated to fit the posts, and a circular opening of suitable diameter is cut in the centre for the lens. The brass front bar C (Fig. 72), $\frac{1}{4}$ in. wide, is screwed across the posts at the top. The slotted brass front plate D is screwed to the left-hand post, a brass screw bush to take a small milled head screw being fixed in the rising front to correspond. The front plate will require to be bent slightly to fit the post; it is shown separately by Fig. 78.

The Reversing Back.—Fig. 84 is an elevation and Fig. 85 a section of the reversing back, which is $5\frac{1}{2}$ in. square, with a central opening $4\frac{1}{2}$ in. by $3\frac{1}{2}$ in. It should preferably be framed up from four pieces. A small triangular portion is rebated at each corner to a depth of $\frac{1}{16}$ in. Two strips $\frac{5}{8}$ in. wide and $\frac{1}{8}$ in. thick are glued parallel with the two longer sides of the opening, and over these are screwed two brass plates A and B, $\frac{3}{4}$ in. wide and $\frac{1}{16}$ in. thick. But the brass plates should not be fixed until the dark-slides are obtained, since they must be adjusted to fit the grooves in these. At C and D (Fig. 84) are glued $\frac{1}{4}$-in. strips of black velvet. The method by which the reversing back is held in the camera is explained by Fig. 79. Two triangular brass plates A and B are screwed at the bottom corners of the recess in which the reversing back fits, and a pair of brass catches are placed at the top corners (see Figs. 80 and 81). The reversing back, being square, can be inserted with its opening either upright or horizontal.

The Mirror.—The wooden back of the mirror is $5\frac{7}{16}$ in. by $5\frac{1}{2}$ in., the upper edge being bevelled to an angle of 45°. It is recessed in the centre, $\frac{1}{8}$ in. from the edges, to a depth of $\frac{1}{8}$ in., and a surface-silvered mirror, preferably of metal, is let in and secured with glue or cement at the sides. The mirror is fixed in position with two small hinges at the back. The release is illustrated by Fig. 82. It consists of two levers made from $\frac{1}{16}$-in. sheet brass, pivoted together with small nuts and washers. The lower lever A has a projecting side piece at one end, bent over at a right angle, as will be understood from its plan (Fig. 83). This side piece strikes the bulb B, which actuates the shutter, when the lever is depressed. The second lever C is pivoted to the underside of the mirror by means of a bent angle-piece, shown separately by Fig. 86.

To the lower lever is soldered a short piece of $\frac{1}{4}$-in. diameter brass rod A (Fig. 83), which passes through a hole in the side of the camera; at the outer end this pivot is filed to a square section for $\frac{1}{8}$ in., in order to fit on the finger release. The latter is made from a piece of sheet brass, as shown in plan and elevation by Fig. 87. The action of the mirror release is easily understood. On pressing the outside finger-piece, the lower lever is depressed, rapidly pushing up the second lever, and, consequently, the mirror; while, at the same time, the projecting piece strikes the pneumatic bulb and releases the shutter. The levers are attached inside to the side of the camera, and should be adjusted by a few trials, so that the mirror just clears the lens before the shutter bulb is struck.

The wooden blocks D and E serve both as stops for the mirror and to exclude light. They are $5\frac{1}{2}$ in. long, and the lower one should be of such a height that the mirror is checked at an angle of 45°. The edges touched by the mirror should have strips of black velvet glued over them. The spring F assists the quick return of the mirror, but if all has been correctly done it will fall by its own weight. Four thin strips of wood are glued to the sides of the camera, just beneath the mirror when lowered and just above it when raised, as shown by the dotted lines in Fig. 82; this is to prevent light reaching the plate by way of the hood. For the same reason, a strip of

thin leather is glued across where the mirror is hinged. The upright lever should be bent, to keep it sufficiently away from the side to clear the lower wooden strip.

The Hood Frame.—This is shown in plan at A in Fig. 90. It is 6 in. square by $\frac{3}{8}$ in. thick, and consists of four pieces joined up. The centre is rebated $\frac{1}{10}$ in. deep, starting $\frac{1}{8}$ in. from three of the sides

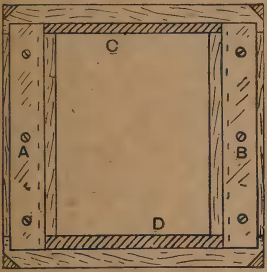


Fig. 84.—Reversing Back

Fig. 85.—Section of Reversing Back


Fig. 86.—Bent Angle Piece

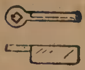


Fig. 87.—Plan and Elevation of Finger-piece


Fig. 88.—Catch for Hood Frame

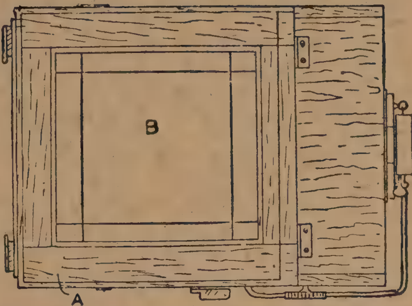


Fig. 90.—Top View of Camera, with Lid of Hood Removed

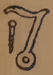


Fig. 89.—Hook Catch and Pin

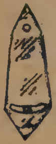


Fig. 92.—Plumb Level

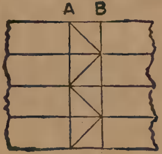


Fig. 91.—Method of Folding Bellows

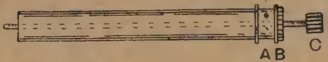


Fig. 95.—Blind Roller No. 1

Fig. 96.—Spindle of Roller No. 2

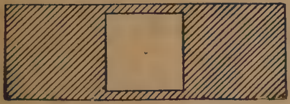


Fig. 98.—The Blind

Fig. 97.—Metal Cylinder

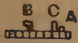


Fig. 100.—Large Toothed Wheel


Fig. 103.—Winding-knob Spring


Fig. 102.—Brass Spring

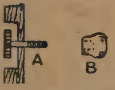


Fig. 99.—Intermediate Wheel, Spindle and Knob

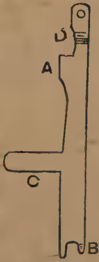


Fig. 101.—Brass Arm

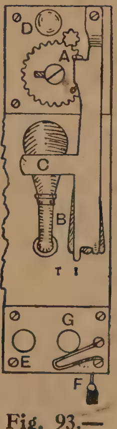


Fig. 93.—Focal-plane Shutter Mechanism

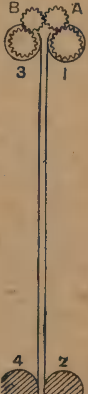


Fig. 94.—Blind and Four Rollers

and $\frac{3}{8}$ in. from the remaining one; this is to allow the hood to lie flat. The frame is attached by a pair of hinges to the top of the camera, and a spring catch of the kind shown by Fig. 88 is fixed at each side, to clip on projecting pins. The hood is made from two pieces of black leather cut to the sector of a circle. The curved edges are neatly turned over and glued, and the sides are glued to the frame and lid respectively. A strip of leather is glued inside along the hinge of the lid. The lid is 6 in. square, and is made of three pieces keyed together. The brass hinges are fixed inside. The lid is fastened with a hook catch and pin (Fig. 89), and is retained in an upright position when in use by an elastic band secured at one end to a staple in the lid, and passed over a screw hook in the camera top.

The Lens.—It is necessary for the lens to be of 7-in. focus. Naturally, a high-class lens working at a large aperture is a great convenience in a reflex camera, the chief use of which is for snapshot work necessitating very brief exposures. The ground glass B (Fig. 90) is $4\frac{1}{2}$ in. square, and is ruled with ink lines to indicate the extent of view included horizontally or vertically. Before fixing it, another piece of ground glass, $4\frac{1}{4}$ in. by $3\frac{1}{4}$ in., should be placed in a dark-slide in the position occupied by the plate, both the shutters being drawn, and the focus should be carefully tested on objects at different distances, to see that it corresponds with that shown on the horizontal ground glass. This should prove to be about right with a 7-in. focus lens, if the measurements of the camera are closely adhered to; if otherwise, the distance must be adjusted by altering the rebate in the frame, or by means of a beading, until the focus exactly agrees with that of the ground glass placed in the dark-slide.

Bellows, etc.—The method of folding the bellows is indicated by Fig. 91, and is soon grasped by a few minutes' practice with some stiff paper before starting on the proper material. First rule with pencil as many parallel horizontal lines on the paper as there are to be folds in the bellows. Then mark two parallel vertical lines A and B, the same distance apart as the horizontal lines; and from corner to corner of the little squares thus formed rule the diagonals, as shown, from right to left and from left to right alternately. Now fold the paper on the horizontal lines; then spread it flat, turn over, and fold again on the horizontal lines, but in the reverse way. If the diagonals are next creased, the paper will readily assume the correct shape of one of the bellows corners. The other three corners are done in the same way. The bellows proper is made of leather backed with black lining. The join is best made midway in one of the sides, that side being placed at the bottom. The ends of the bellows are glued to the partition shown at H in Fig. 73 (p. 71) as well as to the rising front.

The plumb level (Fig. 92) and the leather handle hardly require explanation. All the brass fittings mentioned may be purchased, except the levers for the mirror release. The camera should be given a coating of dull black varnish inside, and may be polished outside; or, if preferred, it may be covered with black leather.

Focal-plane Shutter.—A focal-plane shutter, built into the camera, may be constructed as shown by Figs. 93 to 103. This is regarded as the ideal type of shutter for use in a reflex camera, but the camera already described will need to be made higher, so that the mirror does not get in the way of the top rollers of the shutter blinds, which blinds work just behind the opening at the back. Fig. 93 is an outside view of the mechanism fixed on the left-hand side of the camera nearest the end; the length is shown shortened to save space, which is also the case with the drawings of the rollers.

There are four rollers, arranged as in Fig. 94; Nos. 1 and 2 carry a spring blind, while Nos. 3 and 4 carry a similar blind without a spring, for altering the width of the slit or opening. Roller No. 1 (Fig. 95) is of wood, long enough to go across the width of the camera; it has a square steel spindle, filed round at the ends. A pulley A and a toothed wheel B

are fixed at one end, also a pinion C with six teeth at the extremity of the spindle. Roller No. 2 has a steel spindle A (Fig. 96) threaded to fit the winding knob B.

The spring C is of fine steel wire wound round the spindle as shown, one end being passed through a hole bored in the latter.

The spindle and spring are inserted in a metal cylinder (Fig. 97) closed at one end, the other end being furnished with a tightly fitting disc A with two notches, into which is fastened the second end of the spring.

The blind (Fig. 98) is of thin black rubber cloth, with an opening $6\frac{1}{2}$ in. by $4\frac{3}{4}$ in.; one end is glued round the spring roller, the other being bound round the spindle of roller No. 1 and brought through a slot cut in the wood. Through a hole in the pulley of roller No. 1 is passed a silk cord, which is brought out through a small hole in the bottom of the camera and furnished with a tassel. Rollers Nos. 3 and 4 are of wood, No. 3 having at one end a toothed wheel similar to that on No. 1, while at the opposite end Nos. 3 and 4 are both provided with a small pulley. Roller No. 4 has a winding knob like that on No. 2, but with a pin through it, so that it will wind both ways without unscrewing. The two toothed wheels are made to move in unison, in opposite directions, by two intermediate toothed wheels A and B, as shown in Fig. 94. One intermediate wheel B is attached to a short spindle A (Fig. 99) on which screws a knob B, and the side of the camera is recessed so that the wheel can be put out of gear by pulling the knob.

The ends of the second blind, which is similar to the first, are glued round the spindles and passed through slots in the wooden rollers. An endless cord is passed tautly over the pulleys of rollers Nos. 3 and 4, so that the blind cannot slacken, but may be wound either up or down by the winding knob on No. 4.

The outer fittings work on two brass plates, suitably drilled. The toothed wheel A (Fig. 93) may have about thirty-two teeth; it gears with the pinion of roller No. 1, and has soldered on it three projections, as shown at A, B, and C in Fig. 100. A piece of stout brass is cut to the shape shown by Fig. 101, and bent as at B and D. The catch portion A (Fig. 101) is intended to engage one or other of the projections, on the large toothed wheel, according to the position of the arm. A piece of thin brass is cut as in Fig. 102 and bent up at the sides and in the middle, forming a spring with two hollows in which the turned-down end B of the arm will catch. This spring is screwed to the camera underneath the arm, as at B (Fig. 93); the arm itself being fixed by a screw through the top, so that it will move freely without being loose.

The bulb of the pneumatic tubing is brought through the side of the camera and placed under the wing C of the arm. A spring is made, as indicated by Fig. 103, with a short projection to engage in a slot cut in the winding knob G, and is screwed in place as shown.

To adjust the width of the slit, the knob D (Fig. 93) is pulled, throwing the intermediate wheel out of gear; the winding knob E is then turned until the required width is obtained. The knob D is now pushed back until the wheel engages again. The shutter is set by pulling the cord F. The winding knob G alters the tension of the spring blind, according to the number of turns.

For a time exposure, the arm is moved until the pointer at the end comes against T, which should be marked at the correct position for the arm to engage the grooved projection B (Fig. 100). On pressing the ball the blind is stopped half-way by the projection catching the arm, remaining open until the ball is released, when the arm falls, the groove in the projection permitting the wheel to pass.

Varnishing and Staining

Varnish is applied over paint in order to protect it, presenting a surface better calculated to resist hard usage and one that is more easily cleansed. On some colours, as those ground in water and bound with gum or ale and used in graining, it is absolutely necessary for protection. Some pigments, too, work badly in oil or varnish, so that when required to be finished glossy, supposing enamel is not used, it is found easier to paint them in flat colour, and then to finish with a coat of varnish.

Should the reader be labouring under the impression that there is nothing difficult in varnishing, it is advisable for him to examine the first new high-class motor car that comes under notice, and then to attempt the production of a similar finish. Granted that the work has been filled up, that three or four coats of varnish have been given and felted down, the beauty of the work will not be properly appreciated until an attempt has been made at its imitation. In the matter of conditions, such as equable temperature and freedom from dust or draught, the coach painter usually has the advantage over the house painter, so that in mentioning the finish of the motor-car body, the object in view is to hold up an example worthy of imitation, rather than imply that housework should invariably be of the same high standard.

Kinds of Varnish.—There are two chief kinds of varnish—oil and spirit—but for the general run of varnishing only the first of these is used, the second being employed chiefly by the polisher and wood finisher. In oil varnish, linseed oil is the solvent, and heat is necessary to the proper dissolving of the gums and resins ; in spirit varnish, the solvent is turpentine or methylated spirit, with the second of which any temperature greater than a gentle warmth would mean the evaporation of the liquid. In this chapter not much will be said of spirit varnishing.

Ordinary *inside* oak varnish, if bought from a reliable firm, is suitable for varnishing dark colours and floor margins. On exterior work, *outside* varnish must be substituted ; but when there is not a large amount of work to be done, outside varnish may be employed on both exterior and interior ; but this remark does not apply to inside varnish.

Pale carriage varnish is a much better quality, suitable for front doors, graining, and work generally of a superior kind. For white or very pale tints one of the practically water-white varnishes put up by the best manufacturers should be employed. For wall-papers in bath-rooms and kitchens, paper varnish is used ; for natural wood, and water and oil staining the varnishes mentioned are all that will be required. All these varnishes are oil varnishes, and, as has been suggested, spirit varnishes are seldom necessary in the general run of house-painting.

Preparing Paintwork for Varnishing.—In preparing paintwork for varnishing, the under-coats, with few exceptions,

may be laid in the same order as recommended for gloss enamel. On the dull or flat ground, varnish takes well without fear of its running into rings or "cissing," as it would be inclined to do on an oily ground. Varnishing over a glossy oil paint is not impossible, but it is inadvisable; it may be done by first damping the surface with water in which a little gilder's whiting is dissolved, and wiping with a chamois leather. It is a fault to varnish on paint that is not thoroughly hard, there being the possibility of lifting the paint, and the practice does not conduce to durability.

Applying Varnish.—When applying varnish, a fairly full coat should be given, yet not so full as to run in tears or sag; the brush used should be a clean hog-hair brush possessing plenty of spring in the bristles. Always lay off the way of the panel or grain with a light touch, the lighter the better. The time to leave varnish alone, especially the better sort, can be learned only by experience; but it may be said that after the varnish has been equally distributed over a panel, the less working it receives the better. Excessive working is apt to cause the varnish to froth, the result being that each bubble on bursting forms a miniature hill with a valley in the centre, altogether destructive of a smooth finish.

The conditions under which varnishing is done largely influence the result. It is not always possible to choose or order them, though they are sometimes capable of modification. A temperature of from 60° F. to 70° F. (not always possible), besides freedom from draught, dust, acid fumes, steam, and moisture in any form, are among the essentials to complete success. Damp air or a cold current of air coming into contact with wet varnish of the better sort will cause a white film to collect on the surface, which can only be remedied by revarnishing. Seediness or grit in the varnish sometimes occurs from the same or a similar cause, but more frequently from dirty brushes.

When varnishing outside work, such as a street door in the winter months, it is advisable to select what gives promise of being a dry day, getting the varnish on as early as possible, so as to give it an opportunity of setting previous to the advent of cold air of late afternoon.

Draught may be dealt with by a little forethought in having ready at hand a temporary folding screen covered with common sheeting or some other suitable material. Screens are not used, considering their utility both as draught and dust excluders, nearly as much as they might be, especially when painting and varnishing good-class front doors. After all, there is no doubt that dampness is the greatest enemy to varnish work. For this reason, varnish brushes must on no account be stood in water, but in either linseed oil or varnish mixed with turpentine. Water, like cold air, will turn varnish white.

A good varnish, whether slow or quick setting, should present a film that will not collect dust. In other words, once it is dry it should not be sticky or tacky when touched. Some of the cheap varieties, in which there is a quantity of resin or inferior gums, dry quickly, but soften again when brought into contact with the heat of the hand. Needless to say, they are of little value to the painter.

A good varnish might, however, be unjustly condemned under this head, by using it over old woodwork, such as oak graining, if the surface has not been properly washed either with sugar soap and water or Hudson's powder. A smoky surface, always found on old painted work in large towns, will retard, if not prevent, the proper drying of any varnish, being more obstinate than a greasy one.

Two-coat Varnish Work.—On best-quality plain-painted work, oak, and graining generally, two coats of varnish are essential. The first coat should be given at least a week in which to get hard, when it may be felted down with pumice powder as recommended for enamel in another chapter in this series, and the surface cleansed free of the pumice particles. The following day the finishing coat of varnish may be given; but it is inadvisable to apply it immediately after the felting down. Where two coats of

varnish are given the varnish may be the same, or, better still, the second coat may be slower in drying; but in no case should a quick-drying variety be applied over a slow-drying one; although apparently all right when first done, in a few weeks it is more than probable that the surface will crack, owing to the top film not having the same power of expansion as the one beneath it.

Putting Varnish Brushes Aside.—When varnish brushes are set aside for the time being, they should always be in a closed vessel and suspended in oil or varnish mixed with turpentine. They are then protected from the small particles of dust that are always suspended in the air.

Storing Varnish.—Varnish is best stored in a cool place away from the ground, preferably in a cupboard, as it is likely to become gritty if exposed to extremes of heat and cold. The can should not be unduly agitated; if partly used, it should not be left with a porous cork or with no cork at all, as the varnish will get foul, and, in contact with air, become thick and useless. Properly sealed, varnish will keep almost any length of time, and will improve with age.

Varnish should never be tampered with, but used as it comes from the makers. Such expedients as adding turpentine, boiled or raw linseed oil, or even liquid driers, are to be condemned, as they detract not only from its gloss, but its durability.

STAINING AND VARNISHING

There is a richness of tone in properly stained and varnished work which to many is preferable to either flatting or enamel; and where there is a craze for uniformity of colour, the woodwork of a room may be stained to match the furniture. Staining properly chosen goes well with any scheme of colour.

The whole range of woods from pine to rosewood is within the scope of the painter's art. There are scarcely any limits to the use of stain, whether on wood, paint, or relief materials, while for libraries and dining-rooms no painted woodwork can excel properly selected staining.

Stained and varnished work is both decorative and sanitary, since it will bear repeated washing with soap and water without injury to the surface. Even when signs of wear are apparent, judicious touching up and another coat of varnish will give a result equal to new.

Some years ago it was the practice to stain and varnish the woodwork in working-class houses. This had much to recommend it, since the varnished surface presented a good ground for subsequent painting. It had, of course, to be well rubbed down with pumice-stone and water to break the gloss before paint was applied.

The chief objections to the use of stain arise from the lack of preparation of the surface, it being a somewhat general idea that any wood is good enough to stain. Where the wood is not planed smooth, no amount of staining and varnishing will remedy the evil; in fact, the varnish will make it more apparent. Wood, especially white and yellow deal, interspersed with sap, will show dark patches where the stain is absorbed to an abnormal degree. This is more noticeable where water stain is preferred to oil, owing to readier absorption. It is not always possible to select the wood, since the painter must deal with it as it comes to his hand; but where there is evidence of sappy material, a little preliminary preparation will obviate to a large extent the evil of a patchy finish.

Sizing and Varnishing.—It may be best to mention, first, ordinary sizing and varnishing, since quite a lot of wood, as pitchpine, is simply varnished. This wood deepens with age, and though not a suitable choice for every position, is frequently selected for lecture rooms and other public buildings. The best finish is undoubtedly that where varnish, and varnish only, is used; but this means three and sometimes four coats, these producing a hard, durable surface, unattainable by other means. Where varnish alone is employed, the varnish may be the same for each coat, although it is pre-

ferable to finish with a slower and more elastic kind. The order must not be reversed, because, as already stated, if a quick-drying varnish is applied over a slow one, the film will be inclined to crack.

To lessen the cost of varnishing bare wood, animal size is applied as an undercoat. One coat, and sometimes two coats are given, the material being laid on with a hog-hair brush. The strength of the size should be of a weak jelly when cold. The size is, however, used warm, the first coat being, in fact, hot, and laid on freely without undue brushing. Allow to get dry, then give a second coat, using the size cooler than for the first one. Excessive working will cause the size to froth on the wood and leave unsightly ridges. When dry, the varnishing may be done.

Stopping.—Nail- and screw-holes or other places should be stopped after the first coat of varnish, or where one coat only is given on top of the size. The stopping is made of ordinary putty and oil stainers, and it seems preferable to use on top of the varnish, as in this case there is little risk of leaving dark marks round each hole where the putty has been scraped into the wood. When stopping on top of varnish, it is advisable to have handy a piece of clean rag, and with it lightly pass over the stopping each time so as to remove surplus material round the holes.

It is seldom that the more expensive woods—as walnut, mahogany, and rosewood—are varnished. These generally are polished (for which see an earlier volume), but whenever they are varnished they must first of all be filled up, or the result is far from satisfactory.

Painters' Stains.—Stains for wood may be divided into four classes—water, oil, spirit and chemical; though, so far as the painter is concerned, there is no occasion to trouble about the last. The cheapest, and in many respects the easiest stain to use is water stain, which can be made at home or bought in bottles, used as purchased, or thinned down with water to the required depth. Oil stain is also easily made. Varnish stains—really belonging to the oil class, though frequently to be bought at small oil shops—are not recommended, since they are not so satisfactory as ordinary oil or water stains. Trying to lay a stain and varnish in one operation results in a streaky appearance, which obscures rather than enriches the grain. This is owing to the lack of penetrating power in the vehicle, which is of a gummy nature. Neither are varnish stains to be recommended on the score of cheapness, for by the time a suitable gloss has been built up by repeated coats of varnish stain, a better result would have been obtained by either water or oil stain and subsequent varnishing. Though very well for touching up or dealing with small articles, they are not recommended for large surfaces, owing to the difficulty experienced in obtaining an even colour.

As regards water stains, they may be had in large or small quantities for most woods, and may be diluted, if necessary with water. They are rich in tone, transparent, and cover a large area at little cost.

In making stains at home, choice must be made of the transparent pigments, as raw and burnt sienna, burnt and raw umber, yellow ochre, vandyke brown, rose pink, madder lake, blue black, and prussian blue. Madder and other lakes may be used alone or as a glaze on a dull understain. Where pigments are used they are best purchased ground in water or oil, according to the nature of the stain. Dry colours will do, but they are more difficult to handle. Polishers' stains will be dealt with in a separate chapter.

For water stains, use as a binder weak jelly size—only, of course, brought to a liquid state—or equal parts of stale beer and water.

For light oak use a mixture of raw sienna and umber in the proportion of two of the first and one of the second, using raw umber if a quiet colour is desired, burnt umber if warm. Any number of shades of oak may be made from sienna and umber, or vandyke alone. These colours are also suitable for American

and Italian walnut and teak. For mahogany use vandyke brown and madder, or other bright lake. Satinwood stain may be made from raw sienna and a very little vandyke brown. Green oak stain, sometimes favoured, is made from raw umber and prussian blue.

For water stains, use a stopping made from equal parts of finest plaster-of-paris and whiting before applying the stain.

In oil staining, the pigments mentioned above should be used, the vehicle being linseed oil 1 part, turpentine 2 parts, and liquid driers ½ part, but these proportions may be varied to suit different surfaces. For a very hard wood use more turps, and for a porous surface, more oil and less turps. (Turpentine, turps, oil of turpentine and spirit of turpentine are, commercially, one and the same.)

Spirit stains are made from aniline dyes dissolved in wood spirit or naphtha, to which is added spirit varnish as a binder. Dye stuffs, as dragon's blood, cochineal, and others, are also dissolved in spirit; but where these stains are desired it will be found better to buy them ready made from a good firm.

There is nothing better than good hog-hair brushes with which to apply the stain, a ready-ground oval varnish brush, a No. 8 sash-tool, and a No. 6 fitch in tin being very useful.

Staining and Varnishing a Room.—Let it be assumed that a room with the woodwork in yellow deal is to be stained medium oak. Make the water stain as directed, or use Stephens' stain, trying for shade on a piece of odd board. If still uncertain as to colour, begin on some part least noticeable, such as the inside of a cupboard door. Having ascertained the depth required, the prominent work may be proceeded with.

When staining a door, it is as well to do the panels first, and to avoid smudging the muntins and stiles. Lay the stain freely and evenly, never re-touching a place that is partly dry. Mistakes frequently made are to brush out the stain too much, to use the brush nearly dry, and to re-touch. Rightly applied, provided the wood is in good condition, the stain will be of an even depth. To avoid joints caused through overlapping at the junctions of stiles and rails, cut in clean each time. Where the operator is very quick it may be possible to "bring down" the whole of stiles, rails and muntins together; but it will be found preferable to work them separately, cutting in clean as recommended.

The stain being dry, give two coats of size and then varnish. When applying the first coat of size, do not brush it more than necessary, as there is just the possibility of the stain moving slightly here and there, and such defects can never be properly touched up.

The application of an oil or spirit stain is similar to that of water stain, that is, it is laid on thinly and freely so that it may penetrate the wood. In some instances a good effect is obtained in the case of oil stain only, if, after allowing the stain half an hour to soak into the wood, a clean piece of rag is drawn from top to bottom of each panel, thereby removing some of the material and giving prominence to the grain.

A coat of size is sometimes given to the wood before staining; generally this is undesirable, yet where the wood is very porous, either all over or in large patches, the size has its uses in preventing the wood absorbing so much of the liquid as to make the surface darker than was originally intended. The wood most likely to offend in this respect is the cheapest deal, and cheap ready-made doors, which are seldom planed smooth enough to receive stains.

Yellow pine may be at fault in places only, and these are best treated by touching up either with 1 part of knotting and 2 parts of methylated spirit, or with japan gold-size and turps. Porous wood is doubtless best dealt with by using oil stain, and treacherous wood should have a preliminary coating of either dilute knotting or 2 parts of turps and 1 part of japan gold-size. Ordinary knotting may be 2 lb. of shellac and 2 oz. of pale resin dissolved in 1 gal. of methylated spirit.

DECORATIVE STAINING

Staining lends itself to quite a number of treatments, every one decorative. High gloss is not always desirable, in which case work may be stained and wax polished, or stained and rubbed over several times with refined boiled linseed oil.

While any wood lends itself to staining, this cannot properly be called imitative staining without proper choice of the wood to be treated. Ordinary deal may be stained, so far as colour is concerned, to resemble any wood, but, owing to the grain, it would not deceive anyone. White and yellow deal may be stained to the colour of pitchpine, and if the wood is carefully selected, the appearance would resemble pitchpine. Whitewood can be stained to almost anything, but most satisfactorily to mahogany, teak and American walnut. By the introduction of suitable colours on top, or worked in with the stain, which entails a knowledge of graining, Italian walnut or rosewood effects may be readily produced.

Stain is used in other ways, as over a painted surface, when, though the process is practically the same, it is sometimes called glazing, at others scumbling.

In a room there may be painted woodwork side by side with clean new wood, the intention being to stain the whole. Now, even if a paint solvent is used on the paint, the wood will not be left clean like the new part. Sometimes the painted portion is grained to match the new, but such work is generally beyond the amateur, and the best course, therefore, is to stain on a paint made to match the lightest part of the wood. Give several coats, mixing the last with 2 parts oil and 1 part turps, so that it dries with a medium gloss. For a room of this sort it would be best to use an oil stain, as this could be brushed over the bare wood and the painted surface, with more prospect of success by an amateur. In dealing with the painted part, first lay the stain as level as possible; then, if the grain of the adjacent wood is open, it will be advisable to draw a dry flat brush down the stain while wet, so as to give the suggestion of texture or grain. Sometimes stippling or "flogging" afterwards is an improvement. If it is found that, despite ordinary care, the painted part is not quite so dark as the other, this may be remedied by going over it again with stain much diluted. This should, however, have more oil, and possibly a little varnish added, as if there is an excess of turps there is a likelihood of moving the under-coat.

Glazing Paint.—The practice of staining (glazing) paint is not adopted so much as it might be. The grainer employs it to give richness and depth to his imitations with excellent results, and the glass-writer to produce rich backgrounds at comparatively small cost, but the house painter rarely uses the method. A little thought must reveal the many ways in which stain would be useful. Frequently, the only method of matching a particular pattern of colour is to apply a coat of glaze or stain over a foundation of paint.

This method of glazing or staining on solid colour has not only the advantage of richness, but it is a cheap way of obtaining rich effects. Imagine the cost of building up a deep crimson. It is prohibitive, and there is a doubt as to the permanence of the colours. Yet by bodying with solid colours, and giving a coat of crimson, on a clean, bright under-coat, a good result is obtained.

The madder lakes, crimson lakes, yellow lakes, vandyke brown, prussian blue, blue black, siennas, ochres and umbers may all be employed singly or in combination for giving richness to solid colour. These may be laid evenly with soft brushes, but are always improved by softening or gentle stippling with a badger softener.

The prevailing colour of the most expensive woods may be desired without the figure or grain. For this, the woodwork must be painted the colour of the ground, and then brushed over with glaze or stain prepared either in oil or water, texture being produced by stippling or, in some cases, by flogging the wet colour.

To flog a panel in water-colour, take the badger softener and using it flat—that is, the side of the hairs—begin at the bottom of the panel and lightly strike the wet colour. The badger may also be used if the colour is made of oil, but it will need to be well cleansed afterwards, first with turpentine and then with soap and water. Sometimes brushes of the same shape are made of hog-hair for use with oil-colour.

The ground for light oak may be made from white and yellow ochre, adding a little burnt sienna if it is desired warm. The result is a deep cream; for medium oak, increase the quantity of ochre; for dark oak burnt umber and venetian red are added.

For teak and walnut, use a leather colour made from white ochre, burnt umber and venetian red.

The ground for mahogany varies according to the depth of tone required. The walnut ground with more venetian red added would be suitable, while for dark mahogany, venetian red with a small quantity of burnt umber and a smaller amount of white would be found suitable.

Rosewood requires a dark mahogany ground, except that ochre should be substituted for the burnt umber. On these grounds use the glaze colours previously mentioned.

Stained "Inlays."—By a judicious use of stain it is possible to produce imitations of the finest inlay work, a matter to which attention is drawn in the chapter entitled "Wood Inlaying" in Vol. III.

Staining and Varnishing Floors.—Floors are generally stained in one colour, though there is no reason why a simple marquetry pattern should not be produced. When staining floor margins, oil-stain is preferable, as the wood is generally rough, and should water-stain be used the work will absorb so large a quantity as to turn the wood almost black. It seems a mistake to stain floor margins as dark as is generally done, a shade deeper than the prevailing tone of the carpet being quite sufficient. Avoid the use of combined stains and varnish, which are liable to cause much trouble.

Do not use size on floors; the finished surface will then be more serviceable and better resist the hard wear. A good hard-drying floor varnish or hard church oak should be used. Cheap varnish will not give satisfaction, as either it will quickly lose its gloss or else it will remain tacky for an inordinate length of time, and, as a consequence, capture the dust and fibre in the atmosphere.

It frequently happens that boards have worn bare where the traffic has been excessive, while the remaining part is in good condition. Staining is difficult to touch up successfully. It may be remedied to some extent by re-touching the bare places, and, when these are dry, adding a little stiff stain colour in oil to the varnish and going over the entire surface. Such a proceeding makes the margin a trifle darker, but the result is preferable to a patched surface. As it is found necessary, eventually, to follow this course on all floor margins, there is something to be said in favour of keeping the stain comparatively light in the first instance.

Using a Filler.—With regard to staining or varnishing open-grained woods, the use of a filler is recommended. The liquid fillers sold by the best varnish firms are quite satisfactory. Whiting and turps, or finest plaster-of-paris and water, used thick and rubbed into the pores of the wood with a wad of clean cloth or applied thinly with a brush, are alike serviceable. These, when dry, are rubbed down with fine glasspaper the way of the grain. They may be coloured where desired by adding pigments either dry or ground in water.

Making Microscope Slides

Introduction.—The majority of text-books dealing with modern microscopy generally have several chapters devoted to various methods of preparing slides. The ordinary amateur, after being led through a maze of chemical formulæ, with much serious talk about stains, fixatives, and reagents, comes to the conclusion that the simplest process is entirely beyond his power and understanding. A common fault in many such handbooks lies in the fact that too much information is crowded into a small space, with the result that no single method is fully explained, the main issue being obscured by the quoting of exceptions to the rule, and alternate systems.

In the course of the present chapter an effort will be made to describe certain simple methods which, by the exercise of care, may be successfully carried out by the veriest tyro ; but at the same time it may be stated that no attempt will be made to enter on such higher branches of microscopy as are associated with bacteriology and other pathological studies.

The Instruments.—The outfit for the ordinary microscopist need not be an extensive one, since a large number of instruments is often more of a hindrance than an advantage. The following list comprises all the essentials : a fine scalpel ; two cutting needles ; a few needles mounted in handles, preferably porcupine quills, from which rusted needles can easily be extracted and replaced ; a pair of dissecting scissors ; two pairs of fine tweezers with needle points ; "section lifters" ; half a dozen or more "watch glasses" with flattened bottoms, and a few other small glass troughs, etc. ; pipettes with rubber teats attached ; dipping rods and tubes ; the requisite number of "stock bottles," glass-stoppered, for holding stains and reagents ; some good sable fitch brushes (artists' pencils), size No. 0 or No. 1 ; a turntable and heating table, with lamps or some other source of heat ; and finally a good pocket lens or, better still, a simple form of dissecting microscope. All the articles enumerated may be obtained from dealers in microscopical requisites, and most of them are illustrated by Figs. 1 to 18 on page 84. Certain of them, however, require some further description.

Section lifters are made in a variety of metals, the most expensive being of platinum. They are simply flattened, scoop-like instruments, intended, as their name implies, for lifting delicate objects from fluid. Pipettes may be made from malleable glass tube heated in a gas-jet. Only in the matter of glassware need the microscopist feel tempted to be extravagant. There are many conveniently shaped staining troughs, dissecting and sorting dishes, micro-aquariums, and the like, to be had almost for a few pence each, which materially add to the convenience of the user. Again, at least one dozen good well-stoppered bottles, preferably

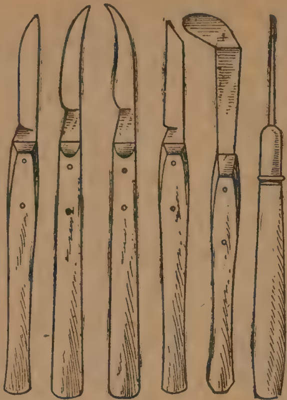


Fig. 1.—Various Knives and Mounted Needle

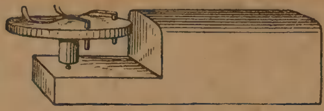


Fig. 2.—Turntable

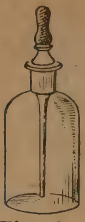


Fig. 3.—Pipette and Bottle

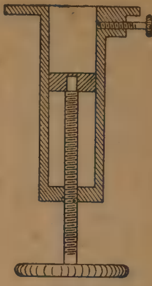


Fig. 4

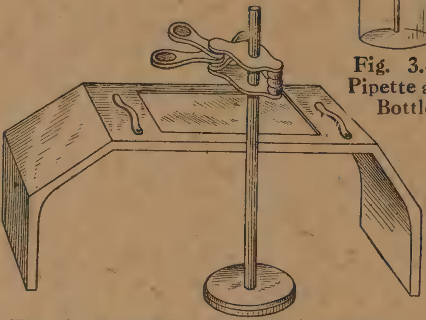


Fig. 6.—Dissecting Stage or Microscope

Fig. 5

Figs. 4 and 5.—Microtomes or Section-cutters

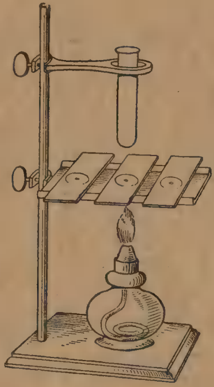


Fig. 9.—Slide-heating and Retort Stand

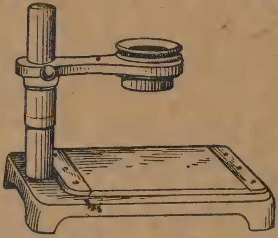


Fig. 7.—Simple Dissecting Stage

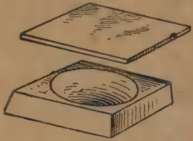


Fig. 8.—Staining Cell

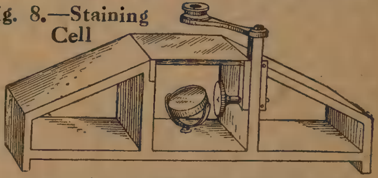


Fig. 10.—Dissecting Microscope

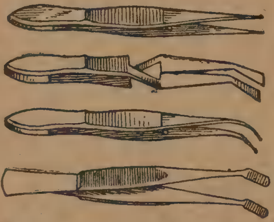


Fig. 11.—Various Forceps for Slips, Covers, etc.

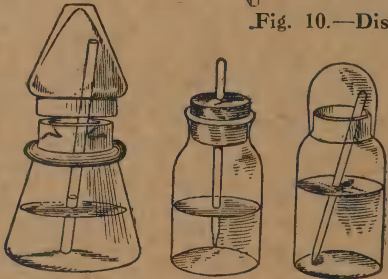


Fig. 13.—Balsam Bottles

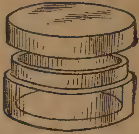


Fig. 14.—Glass Box or Capsule

Fig. 15.—Tripod Dissecting Microscope

Fig. 16.—Dissecting Forceps

Fig. 12.—Dissecting Forceps

Fig. 17.—Curved Scissors

Fig. 18.—Straight Scissors

with permanent labels, are almost essential. The specially constructed canada-balsam bottle can hardly be dispensed with, if the mountant it is destined to hold is to be kept absolutely clean.

The turntable consists of a small circular piece of brass, fitted with clips to hold a slide, and revolving on a pivot fixed to a solid base of hardwood. The heating table should be of fair size, if work of an extensive character is to be performed. It consists of a flat sheet of brass supported on four legs about 10 in. high. A metalworker would make such an article cheaper than it could be bought in the ordinary way. The heat can be produced either by a series of gas-jets or by the use of small paraffin lamps. A wooden cover of box form is a desirable adjunct, if a number of slides are to be accumulated before they are finally finished.

A good lens is essential. A triplet magnifier is very useful in a variety of ways; but higher power is also necessary, and a good lens for the purpose is one of Browning's "Platyscopic," giving fifteen diameters.

There can be no doubt, however, that a dissecting microscope renders the task of dealing with minute objects a comparatively easy one; in fact, for high-power work such an instrument is almost necessary. The "Simplex Dissecting Microscope," made by Leitz, of Wetzler, which gives ten to twenty diameters, can be thoroughly recommended for such a purpose, fulfilling as it does the additional office of a compound instrument of low power.

As this chapter deals exclusively with the mounting of simple objects, no mention will be made of the special instruments required for the various processes of section cutting.

The Materials.—Passing now to a consideration of the materials, there is a somewhat formidable list of necessary chemicals. The following, however, represent the bare essentials required for ordinary work, which in a number of cases had better be purchased for use from dealers. Pure methylated alcohol or rectified spirit standing at 30, 50, 70 and 90 per cent., at which latter strength it is usually sold (rectified spirit, or sp. vini rect.) by chemists, absolute alcohol, pure turpentine, xylol, pure hydrochloric acid, chloroform, pure sulphuric ether, formaldehyde 40 per cent. aqueous to make a 5 per cent. solution with distilled water, oil of cloves, canada balsam in xylol, styrax in chloroform, glycerine jelly, gold-size (artists' quality), marine glue solution, ringing fluid or asphalt varnish, and the stains known as Grenacher's carmine, Ranvier's picro-carmine, Louis Jenner's eosin-methylene blue, Delafield's hæmatoxylin, chromic acid 4 per cent. in alcohol at 30 per cent., together with certain of the aniline colours, such as methylene green, nigrosine, etc.

Space precludes the giving of recipes for the preparation of any of these chemical agents, but a word or two may be said with reference to those most important ones, the mountants, and ringing fluid.

The canada balsam in xylol is entirely distinct from the balsam "treacle" to be obtained from a chemist. Strictly speaking, it is the "treacle" itself evaporated or baked down to complete hardness, pulverised, and then soaked into liquid state by the addition of xylol. Pure benzole is often employed instead, but possesses certain disadvantages. When purchased from dealers, the material should be of a brilliant amber colour and perfectly free from specks of dirt, dust, etc., capable of being examined critically with a lens. It should, moreover, run freely from the end of a glass rod, but if too thick can be diluted by the addition of more xylol.

Glycerine jelly is generally almost colourless, but if preserved, as it often is, by the slight addition of creosote, it may present a yellow tone, which, however, in no way detracts from its quality. For purity it should stand the same tests as the balsam; but being a mountant which is used in a warm condition, it should have, as its name implies, the flaccidity of ordinary size.

Styrax, or storax, which is used almost exclusively for mounting diatoms, being

of much lower refraction than balsam, is of a dark brown tint, and should be slackened to a greater extent than balsam.

There are several other solid or "dry" media for mounting, but they need not be discussed here.

"Ringing fluid" for decorating slides made with circular cover-slips may be of a variety of colours; but as the use of two or more tints simply gives a questionably attractive appearance to the preparations so treated, attention may be confined to the more business-like black or asphalt varnish with which most professionally-made slides are finished. When purchased from dealers, this material is seldom in a suitable condition for immediate use. Generally it is too thick, and requires slacking with equal parts of turpentine and xylol until it runs freely. Sometimes, however, it does not contain enough gum, and in that case a small proportion of powdered dammar or mastic broken down with xylol may be added. This preparation is quite different from brunswick black, which is often recommended, although quite unsuitable.

The slides in general use measure 3 in. by 1 in. Preferably they should be of tinted glass, well flattened and polished, having ground edges. The finer the quality, it is almost needless to say, the better will be the result. Chance's "Crown" and "Superfine Crown" are perhaps some of the finest, and at the same time cheapest, slides on the market. Cover-slips are made in several sizes and thicknesses. The most convenient, and at the same time economical, for general purposes are those of No. 2 grade. Circular cover-slips should be used in preference to those of rectangular form, and for convenience of working, it is generally most desirable to keep to one or two sizes—for example, $\frac{3}{4}$ in. and $\frac{5}{8}$ in.

Cell rings of ebonite and metal are also necessary and these should be procured of varying thickness and matching the cover-slips in diameter. Upon the careful selection of labels much of the final appearance—it might be said the "cabinet appearance"—of slides depends. It is a good plan to adopt from the first a square label of good quality, and of a type which can be readily and accurately matched at any time.

In making preparations of several types a mounting slab is very useful. This consists of a sheet of card showing the size and extent of a 3-in. by 1-in. slide, with the exact centre marked. Such an accessory can be made in a few seconds by placing a slide in one rectangular corner of a piece of millboard, and, having marked round the two free edges with a pencil, drawing two diagonal straight lines between opposite distant corners. The centre is shown at the point where these two lines cross.

Mounting Dry Objects for Direct Lighting.—There are many microscopic objects that cannot be rendered transparent, and which, by reason of their hard nature, can be preserved by the simple process of drying. Amongst these, mention may be made of such things as the wing scales of insects, wing covers of elytra of beetles, etc., the zoaria or cells of polyzoa, mosses, lichens, etc. Such objects can be examined by the compound microscope to the best advantage, either by the parabolic reflector with dark ground illumination, or by the more simple method of direct lighting.

In dealing with such material, the depth of the object should first be roughly estimated and a suitable cell ring in ebonite selected. The slide should then be cleaned thoroughly by means of a soft silk handkerchief moistened with spirit to which a few drops of hydrochloric acid have been added. The cell should then be attached with the marine glue solution and the slide set aside until the adhesive has completely hardened, in, say, a matter of twenty-four hours or so. The object to be mounted may then be rendered entirely free from dust by careful use of the sable brush, and after all superfluous glue has been cleared away from the edges of the cell by means of the knife and the application of xylol on a piece of soft rag, it may be attached to the immediate centre of the preparation with a speck of fish glue. The slide should then be centred on the ringing table, and when the adhesive has

set sufficiently to prevent the object becoming dislodged, the table may be revolved, or, rather, spun rapidly, and an even zone of cement applied with the brush to the extreme outer edge of the upper surface of the cell ring. The cover-slip, which up to this point may be conveniently kept in spirit, should now be cleaned and polished ready for fixing. Upon the skill with which this is applied much depends. The best plan consists in taking hold of the edge with the tweezers, and after fixing the distant side firmly on to the adhesive, allowing the remainder of the cover-slip to fall gently down into place. When once in position the edges of the glass may be firmly fixed by gentle pressure, and then an outer ring of cement can be lightly run on.

When objects of no great depth are to be mounted, the vulcanite ring can be dispensed with and one of gold-size or marine glue solution built up with the brush on the slide itself. As this process, however, necessitates several applications, the one placed after the former has completely hardened, it is a good plan to make two transverse lines on the ringing table showing the correct position of the slide when centred, together with two short upward strokes on the side away from the bases of the clips, which in turn may be made to correspond with ink marks made on the slide itself. Thus on replacing the slide on the table for further treatment the original centre can be found immediately.

Mounting Objects in Liquid Cells.—The process known as liquid mounting has of recent years been considerably facilitated by the introduction of formaldehyde, which is a preserving fluid having an aqueous base. In the early days of microscopy, the media employed for such work (alcohol, glycerine, a mixture of the two, etc.) all possessed considerable disadvantages in use, the worst, perhaps, being the difficulty of rendering the cell hermetically sealed. With the use of a 5 per cent. solution of formaldeyhde, and the exercise of care in the making of the cell, it is possible to produce preparations which appear to be permanent.

For minute delicate objects which would shrivel under the balsam treatment to be described later, such things as noctiluca, volvox, medusæ of hydrozoa, certain algæ and protista generally, and again larger subjects intended for dark-ground illumination, such as those exquisite objects, expanded hydroids; even hydra itself, polyzoa, and entomostraca with fine filamentary attachments to the antennæ, etc., the process is admirably adapted; in fact, it may be said to succeed where all others fail.

The preparation of the cell is similar to that already described; but if a vulcanite ring is employed, in order to ensure a complete and thorough adhesion of its lower surface to that of the slide, the whole of the preparation should be slightly heated and pressure brought to bear until the cement has completely hardened. A satisfactory joint is shown by the cell ring appearing dead black from below, without any glistening areas, these showing where light is reflected from adhesive portions which have not come into direct contact with the glass.

The specimen should be preserved for some weeks beforehand in a 5 per cent. solution of formaldehyde, to which has been added a few drops of liquor ammoniæ. Before mounting, and if of large size, it may be cleaned, if necessary, by the careful use of the sable-hair pencil, and washed in two or more changes of the solution by means of a pipette. The mounting solution of formaldehyde should always be made with distilled water and rendered slightly alkaline. Moreover, it should be allowed to stand for a day or two in a well-stoppered bottle before being used.

The prepared slide, having been centred on the turntable, should receive, as before, an application of the marine glue solution run well on to the outer half of the cell ring. The specimen may then be placed within and the cell filled with the mountant by means of a pipette almost to overflowing, at any rate until the fluid arches well above the level of the cell. The cover-slip, held as before with tweezers, may then be placed in position, the outer

edge being firmly fixed before the remainder is allowed to fall gently down into place. In the escape of superfluous liquid the specimen itself may make its way out of the cell, and to prevent this happening a certain amount of raising and lowering of the cover-slip may be necessary; but during this process the tweezer points should always be kept between the glass and the cell. When the cover-slip has been finally placed, slight pressure should be applied to the edges in order to cause the adhesive to attach. In no circumstances, however, should weight be brought to bear on the centre of the preparation, for apart from the danger of breaking the cover-slips, such treatment results in an ingress of air, causing a bubble to appear. Many microscopists consider that a bubble or small air space is essential to prevent changes of atmospheric pressure affecting such preparation; but the writer, after an extensive experience with such mounts, has never known of a cracked cover-slip or other accident as a result of the omission of this certainly disfiguring feature.

In mounting protozoa, rotifers, and other minute objects by this method, it is always more satisfactory to have a sample thick enough to withstand the draining-off of the superfluous liquid. But where only a few specimens are available, the placing of a fine wisp of cotton-wool within the cell, in which the objects become entangled, is a practice permissible to the tyro in microscopy; experience, however, will soon render it unnecessary.

Immediately after the cover-slip has been fixed the moisture on the slide and turntable should be completely dried up with a duster and blotting-paper. A further application of adhesive can then be made to the edge of the cover. Special stress may be laid on the necessity for covering only the outer half of the cell ring with cement before the cover-slip goes on. This is essential in view of the fact that the subsequent pressure would otherwise cause the material to run into the interior of the mount, to its complete disfigurement.

Glycerine Jelly Mounts.—Glycerine jelly as a mountant is most useful when but moderate transparency is required. On account of the necessity for little or no previous preparation of the object to be mounted, it lends itself admirably to the making of temporary mounts, but for this purpose the material known as "Farrant's medium," is more generally employed. Specimens intended for permanent preservation should be treated in the first place by immersion for at least a week in a 5 per cent. solution of formaldehyde in a mixture composed of equal quantities of glycerine and distilled water. From this medium a change should be made to pure glycerine for a period of about two days. Certain material which has already been prescribed in formalin such as entomostraca, minute larvæ of insects, etc., often does not require this previous treatment, but after being washed in distilled water is ready for immediate mounting.

A cell ring is often necessary when the object to be mounted possesses any depth, but when the specimen is flat and broad this can be dispensed with. The glycerine jelly should be heated to complete liquefaction in a water bath, and the specimen having been placed in position, a sufficient quantity of the mountant is taken up in a clean pipette and run on. The cover-slip may then be applied immediately; but as there is some danger of the object moving during the operation, it is better to allow the jelly to set completely, covering the mount meanwhile with a watch-glass, then to warm the cover slightly and put it on in the usual manner. In dealing with very minute objects, in the preparation of which no cell ring is required, the use of too much mountant should be avoided. Experience alone can teach the user exactly how much will be required for each preparation.

As soon as the jelly has hardened the overflow should be carefully removed with a damp cloth, and a thick zone of gold-size applied to the edge of the cover-slip and on to the surface of the slide itself. As this material shrinks considerably on drying, two or more applications

may be made, the object being hermetically to seal the mountant, which has a nasty habit of coming through minute bubble-holes, forming thereby beads of fluid on the surface of the outer ring, etc. The only difficulty in glycerine-jelly mounting lies in the avoidance of air bubbles. These are generally due to the fact that the mountant has been overheated, either in itself or by the application of a cover-slip at too high a temperature to a cold preparation. Sometimes, if the medium contains too much gelatine, it is impossible to work the bubbles out with the needle before the mount has hardened.

Canada Balsam Mounting.—This method of preparation is the one most generally in vogue amongst microscopists for dealing with a variety of objects. It might almost be said that any organic matter not too frail to withstand the dehydrating and cleaning processes about to be described can be successfully treated thereby. If an object possesses in itself sufficient pigmentation to remain critically visible after mounting, there is no necessity to heighten the substance of the tissue by the use of stain, unless, of course, differentiation is to be shown. Insect parts, foraminifera, chemical substances, etc., as a rule mount successfully without staining; but such things as semi-transparent entire animals, sections and the like, generally require treatment of this character.

With regard to the numerous stains in common use amongst microscopists, in a general way it may be stated that Grenacher's carmine is useful for all ordinary purposes in dealing with entire animals or animal tissues, Ranvier's picro-carmine also, but its use is somewhat more restricted. Hæmatoxylin is principally utilised in botanical work, but in weak solution gives excellent results with animal tissues, etc., intended for photomicrography. Louis Jenner's eosin-hæmatoxylin double stain is selected from a number of others equally efficient for the double staining of blood smears, etc. The group of aniline colours also included in the list are useful for a variety of purposes; but they are not stable, and with the exception of certain colours, such as methyl green, safranine, nigrosine, etc., fade partially or completely on being heated.

With any object intended for balsam mounting the following processes are essential. When originally preserved in formalin, or in a fresh condition, it should be immersed in a sufficient quantity of alcohol at 30 per cent. and allowed to remain for about ten minutes; successive changes of the same duration are then made through the higher strengths of 50 per cent., 70 per cent., 90 per cent. to absolute, and from thence into the clearing agent, oil of cloves. From this medium the object may be passed directly into the mountant. If staining is performed with Grenacher's carmine, the 50 per cent. change may be omitted, the specimens being placed in this liquid for about ten minutes, and from thence into 70 per cent. alcohol to which a small proportion of hydrochloric acid has been added. The subsequent treatment follows as described. Delafield's hæmatoxylin usually stands at about 30 per cent., and after the specimens have been placed in spirit of the same percentage a change may be made directly into the stain, which should be filtered before use and diluted to about a quarter of its original strength by the addition of 30 per cent. alcohol. This stain is rather violent, and a few minutes generally suffice for it to strike thoroughly. Objects treated with it subsequently require washing in slightly alkaline water, which develops the full purple tone of this attractive stain.

The aniline stains as a rule do not keep well in stock solutions, and as the percentage of the several varieties in common use varies considerably, and their mode of preparation also, it is impossible to detail even briefly formulæ for their general employment. The amateur cannot do better than obtain a necessary supply of the required colours in the form of Burroughs, Wellcome & Co.'s "Soloid" stains, to each of which directions for use are given.

The simplest form of blood staining for the differentiation of the phagocytes and

leucocytes consists in the use of the combined eosin-methylene blue method (Louis Jenner's process). A drop of blood should be taken on the narrow end of a 3-in. by 1-in. slide and passed rapidly across the surface of a well-cleaned cover-slip. The film thus formed should be allowed to dry in the air, and the stain poured directly on to it and allowed to remain for five minutes, covered meanwhile with a watch-glass. The stain itself can be most conveniently prepared by dissolving one "Soloid product" in 10 c.c. of pure methyl alcohol (90 per cent.). The cover-slip should subsequently be washed in distilled water until the green tint of the film has given way to red. Then, after draining on blotting-paper and drying in air, the whole may be mounted directly in balsam.

Little has been said with reference to the actual process of transferring the object to the mountant. The section lifter should always be used when dealing with delicate objects, being slipped underneath the specimen, which in turn may be worked off on to the surface of the slide, together with a certain quantity of clove oil. A certain amount of arrangement is necessary with the needle before the balsam can be applied, and when this has been dropped on from the dipping rod, no time should be lost in placing the cover-slip.

The most suitable cell rings for balsam mounts are those of pure tin, penannular in form. The mountant on hardening collapses considerably by the loss from evaporation of the xylol, and more has to be run under the cover-slip. It is apparent, therefore, that with a closed cell ring a bubble would make its appearance.

Finishing and "Ringing" Slides.—Before a slide mounted with balsam can be finished, the mountant itself must be reduced to a condition of comparative hardness. If dried in air this process occupies several months, and the preparations require filling from time to time as the evaporation continues. To hasten this the heating table is generally employed. The slides having been allowed to stand for a day or two, are then subjected to a temperature of about 130° F. for a period ranging from three to six days, according to their thickness. When the balsam begins to change colour from light to dark yellow it is an indication that the heating has been sufficient. Throughout the process the balsam bottle should be kept constantly in use to fill up the loss.

Slides thus treated should be allowed to cool thoroughly. Superfluous balsam may then be scraped or rather flaked away with an old scalpel, and the surface of the slide rendered brilliant and clean by the application of a little xylol on a soft duster.

"Ringing" of all preparations with the black asphalt varnish is performed in the following way: The slide is centred accurately on the turntable and spun rapidly. The first ring, which is made exactly of the required depth, is then run on with a sparingly filled brush held obliquely. A second application is then made with the brush fairly full and held almost vertically, the varnish being allowed thereby to trickle down into the channel formed by the first ring. The brush should be cleaned with xylol on a piece of rag as soon as it becomes clogged. This is certainly an operation requiring skill, born of experience; but it may be remembered that the two essential factors towards success are a good brush and varnish in perfect condition.

Labels for the finished preparations should be written as neatly as possible and drafted in the following manner: First label—natural order to which the specimen belongs, the genus and species, also the authority for the latter; the part shown. Second label—the locality from whence the specimen has been derived; for what type of illumination the object is intended, and the optical combination of objective and ocular most suitable for its examination; the stain, if any, used in preparation, and the mountant. These several particulars will generally be found to occupy the space afforded by the labels of the type already described.

Silvering and Bevelling Glass

Many processes for the silvering of mirror glass and optical parts have been introduced at various times, but the number in practical use is small. The best-known processes are: (1) The old Mercury-tin Amalgam Process; (2) The Formalin Process; (3) The Rochelle-salt Process; (4) The Tartaric-acid Process; (5) The Brashear Process.

The Mercury-tin Amalgam Process.—In view of the lengthy period required for completing this process, and of the danger to the health of the worker due to possible mercurial poisoning, coupled with the somewhat poor reflecting surfaces of mercury mirrors compared with those of the silver variety, this process may be dismissed without further consideration, except, possibly, it is worthy of note that some sea-going officers still favour the use of mercury mirrors owing to their durability.

Patching Damaged Old-style Mirror.—The amalgam method is useful, however, when the silvering of a mirror of the old type needs to be repaired. First clean the bare portion of the glass by rubbing it gently with fine cotton, taking care to remove every trace of dust and grit. If this is not done carefully, defects will appear round the place repaired. Outline on the back of a spare piece of mirror (a piece can often be bought for a few pence) a patch of silvering of the required form but a little larger, and with the point of a penknife cut through the amalgam along the outline. On this piece of amalgam place a small drop of mercury. The mercury spreads immediately, penetrates the amalgam to where it was cut through with the knife, and the required piece may then be lifted and removed to the place to be repaired. This is the most difficult part of the operation. Then press lightly the renewed portion with cotton. It hardens almost immediately, and the patch is not unduly obvious.

Another way (mercury-tin amalgam) is to pour on a sheet of tinfoil about 3 dr. of quicksilver to the square foot of foil. Rub smartly with a piece of buckskin until the foil becomes brilliant. Lay the glass on a flat table, silvered side uppermost; place the foil on the damaged portion of the glass; lay a sheet of paper over the foil, and place on it a block of wood or a piece of marble with a perfectly flat surface. Place sufficient weights on it to press it down closely, and let it remain in this position for a few hours. The foil will then adhere to the glass.

The Formalin Process.—This process is simple and rapid, but the surface is dark and one deposit cannot be placed upon another.

The Rochelle-salt Process.—This is widely used, as it affords a brilliant reflecting surface, which, however, is from 5 to 6 per cent. less brilliant than that obtained by the Brashear method (see later). The silver is deposited at a normal temperature.

The Tartaric-acid Process.—Surfaces produced by this process are almost equal to those obtained from the Rochelle-salt process. From the point of view of the optician, the process has the drawback that best results are forthcoming only when the bath is heated to about 114° F. (40° C.). To subject finished optical parts to this temperature is obviously undesirable; but this objection is not applicable to such work as large flat mirrors, in which case steam-heated tables are used, and only a single deposit of silver is necessary.

The Brashear Process.—The Brashear process is the one most extensively used for silvering optical and commercial mirrors, and its great advantage lies in the fact that it is a cold process, which gives excellent results at a temperature between 50° and 68° F. (10° and 20° C.). It is not unusually complicated and the resulting coating is brilliant, comparatively hard, and adheres well to the surface of the glass. Coatings of any desired thickness can be obtained by successive deposition, and the layer can be burnished. Thus this process is by far the most efficacious, and in view of its ease of working, low cost, and the circumstance that no special apparatus, such as steam-heated tables, etc., is necessary, it is deemed expedient to deal chiefly with that process, although mention will be made also of the formalin process because some workers doubtless place rapidity before high efficiency.

PRACTICAL DETAILS OF THE FORMALDEHYDE PROCESS

Standard Solutions.—(1) *Silver Nitrate Solution.*—Dissolve one drachm of pure nitrate of silver in 4 oz. of distilled water, and add liquid ammonia (specific gravity 0·880) drop by drop and with constant stirring until the solution is turned a muddy brown colour. Then add a little more ammonia until the solution has a slight colour, its appearance being that of clean water to which a little milk has been added. This is most important, as the silver solution positively must not be over ammoniated. The solution is then ready for use.

(2) *Formaldehyde Solution.*—Mix from 8 to 10 drops of formaldehyde with 4 oz. of distilled water and keep for a day or so. It is essential that the formaldehyde used be of the very best quality. The solution should be kept well corked, otherwise its strength will vary.

Depositing the Silver.—Clean the glass thoroughly with distilled water until the water clings all over its surface. Then drain off and mop well the surface with the silver nitrate solution, keeping the silver nitrate on for at least one minute. Mix about 1 part of the silver solution with 2 parts of the formaldehyde solution, and pour the mixture gently over the glass surface. See that the liquid is kept in motion during the process of silvering, which should not take more than two minutes in a room at moderate temperature. Wash the silvered surface thoroughly with distilled water and stand the glass on edge to dry.

Polishing the Silvered Surface.—With a pad of chamois leather go lightly over the surface of the silver deposit, using some fine washed rouge. First be sure that the deposit is quite dry. The silver film should be hard, and should take on a brilliant black polish, which with care in treatment should last a number of years.

PRACTICAL DETAILS OF THE BRASHEAR PROCESS

The method employed at Greenwich Observatory for silvering large reflectors is essentially the Brashear process with slight modifications, its merit being that it affords a hard enduring film which will withstand a considerable amount of polishing. The following is largely due to a discussion on the making of reflecting surfaces held by the Physical Society of London and The Optical Society in November, 1920.

The formula as used is as follows:

(A) 10 per cent. silver nitrate solution, prepared by dissolving 11 parts by weight of pure silver nitrate per 100 parts of distilled water.

(B) 25 per cent. strength ammonium hydrate (0·880 sp. gr.).

(C) 10 per cent. caustic potash solution, prepared by dissolving 11 parts of pure caustic potash per 100 parts of distilled water.

(D) Reducing solution: distilled water, 2,000 c.c.; sugar, 180 grams; nitric acid, 8 c.c.; alcohol, 350 c.c. A, B and C may be made up as required. The reducing solution (D) needs to have been made up several months before it is required, as when freshly made it is not very active. It may be improved by boiling, the alcohol being added after it has cooled.

The silvering bath is made up in the following proportions: A (silver nitrate), 20 c.c.; B (ammonia), 10 c.c. (more or less); C (caustic potash), 10 c.c.; D (sugar), 5 c.c.; distilled water, 100 c.c.—Total: 145 c.c.

To prepare the bath: Of A (silver) take, say, 100 c.c. and to this add B (ammonia) gradually. The solution at once turns brown. Continue adding ammonia, in small quantities, until the solution clears or nearly clears. Now of C (potash) add 50 c.c. The mixture will again become turbid, turning dark brown. Again slowly add ammonia as before, keeping the solution agitated until it again clears. The solution now possesses a pale brown colour, but transparent. This part of the operation is the critical one, as it is most important to avoid an excess of ammonia. In fact, it is absolutely necessary to have a slight excess of silver in the solution, and this is secured by now adding silver nitrate drop by drop until the solution will take up no more and a little brown matter is left in suspension.

To 500 c.c. of distilled water add 25 c.c. of D (sugar). When the silver-potash solution is added to this the bath is completed, but this must not be done until the mirror is ready for silvering.

Procedure.—A glass may be silvered either face upward or downward as circumstances decide. Small work is preferably silvered face down, but large mirrors are more easily handled face up. The dish for the bath should be of glass or porcelain, but large baths may be of wood or sheet-metal thickly coated with paraffin wax, and for economy should be of nearly the same size as the mirror to be silvered. In the case of very large mirrors it is most economical and convenient to make the mirror itself form the bottom of the bath.

The following is the procedure when silvering a 30-in. (900 sq. in.) mirror. The walls are made by wrapping a band of paraffin-waxed cartridge paper about five inches wide two or three times round the mirror, leaving about three inches above the surface, and sealing it to the glass with paraffin wax. The making of the joint between the paper wall and the edge of the mirror is important, as any small crevices which are left serve as pockets to retain the nitric acid with which the mirror is cleaned. This is avoided by not winding the paper straight on to the mirror, but first introducing a paper packing ring about $\frac{1}{4}$ in. thick, the top of which comes $\frac{1}{4}$ in. below the edge of the glass. The paper band is wound on over this, and a channel $\frac{1}{4}$ in. in depth is left between the paper wall and the mirror, which is filled by running in hot paraffin wax. This makes a smooth clean joint from glass to paper which has proved perfectly satisfactory, and a sectional view of the edge of the glass is illustrated in the diagram.

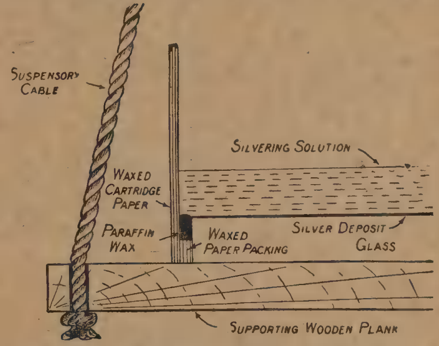


Diagram illustrating Brashear Process of Silvering Glass

The dish is now ready. The mirror is supported by an iron ring with three lugs, and with cords and tackle is suspended at a convenient height so that a conical rotary motion may be given to it when the silvering solution is poured on.

The cleaning is one of the most important operations. Unless the work is absolutely clean, failure must result. All dust is removed, and, if the mirror is being re-silvered, the old silver cleaned off with strong nitric acid, using a swab of cotton wool. Considerable pressure should be applied, and the swabbing should be very thorough. Wash with water and swab again with nitric acid. Rinse off the nitric acid, using plenty of ordinary water followed by distilled water. Finally, leave the mirror standing completely covered with distilled water. It is now ready for silvering. In the cleaning operation it has been recommended that the nitric acid should be followed with a swabbing with caustic soda, but experience is against this, the nitric acid being more easily removed than the potash.

Now proceed to prepare the bath.

For a 30-in. mirror 8,000 c.c. of solution is required, which suffices to give a minimum depth of about 1 c.m. Of A (silver nitrate) take 12,000 c.c.; B (ammonia), 600 c.c.; C (potash), 600 c.c., made up as described above, and distilled water, 6,000 c.c.; D (sugar), 300 c.c.

A temperature of 65°–70° F. is recommended as giving the best results, but with a 30-in. mirror a temperature not much above 55° F. has been found satisfactory. It may be taken, however, that if the temperature is too high, reduction will be too rapid, and the resulting film soft; whilst if too low, action is very slow and the film too thin.

We left the mirror covered with water. This is now thrown off and the water and sugar poured on; then the prepared silver-potash solution is added. At the same time a conical swing is given to the suspended mirror so that a continuous wave passes round the bath. This must not cease until the exhausted solution is thrown off. The drawback to the Brashear process is the formation of sediment, which must be prevented from settling on the mirror surface by keeping the solution constantly in motion. This may further be assisted in the following manner.

Immediately the prepared silver is added to the water and sugar it begins to darken, and in two or three minutes there will be a visible coating of silver. As soon as there is an appreciable deposit it will be found tough enough to withstand light swabbing with cotton wool. Using rubber gloves, the operator takes a handful of cotton wool and draws it lightly over the surface, exerting no pressure beyond the weight of the swab itself. This will disturb the heavy sediment, which, as the bath gets thicker, the motion of the solution is unable to prevent falling. As the cotton becomes dirty it is thrown away and a fresh handful taken.

It is a difficult point to decide when to throw off the solution. If too soon, the film will be bright but thin. If too late, the deposit will be thicker but clouded and will require much polishing. The former alternative is preferable. One must be guided by preliminary experiments and practice.

When the silvering is judged completed, throw off the spent solution as quickly as possible, tear off the paper wall and wash thoroughly with distilled water. If lightly swabbed during the washing much of the cloudy bloom on the surface will be removed, and when dry it will be found to require very little polishing. Stand the mirror in a tilted position to dry, and in an hour it will be ready for polishing.

The polishers are made of best chamois leather stretched and tied over a ball of cotton wool. Two are necessary. First with a plain rubber go over the entire surface with light circular strokes, dusting constantly. Then rub a little rouge into the other and repeat. If the film is a good one it will take a high polish with very little rubbing and with very little scratching. The rubber must be scraped intermittently, otherwise any particles that may be polished off will cause scratching.

Preservation of Mirrors.—The red paint applied to the backs of mirrors to protect the silvering from damp and mechanical injury may be made by mixing 4 oz. of finely ground red-lead with 2 oz. of paper varnish and 4 oz. of turpentine. A second coat is given twenty-four hours

after applying the first, and a very soft brush is used.

It is not wise to hang a mirror on a damp wall or even on a newly-papered one. Where such a position for the mirror cannot be avoided, it is well to tack $\frac{1}{4}$ in. thicknesses of bottle cork on the back of the frame—one at each corner—so as to allow a current of air to pass between the mirror and the wall. Another preventive is to cover the whole of the back of the mirror with flannel, and over this to place a sheet of Willesden two-ply or four-ply damp-proof paper, both flannel and paper being attached by small tacks or by means of a waterproof cement to the frame.

BEVELLING GLASS

The bevelling of glass is work that cannot easily be done by the amateur, inasmuch as for reasonably quick work an elaborate plant of grinding discs, stones, and wood wheels fed with pumice powder, etc., is usually required; but as occasionally there will be a reader who has at his disposal the equipment of a good machine shop, and as the subject is one with regard to which amateurs often put queries, an outline of the process will here be given, basing the information on a description of the work published in "Furniture Record," by Mr. George W. Mueller.

The first machine to receive the glass is the roughing mill—a steel disc 2 in. thick and 30 in. in diameter, set to revolve horizontally. Directly over it are suspended hoppers containing sand and water which are automatically fed on to the revolving disc as required. The operator holds the plate of glass on the revolving disc at the required angle, which is determined by the width of bevel desired. The sand and water on the revolving disc grind away the glass, leaving it very rough. To remove the coarseness, the plate is run over the emery mill, which is identical with the roughing mill except that emery replaces the sand. After the emery grinding, the appearance is still that of ground glass, but the grain is finer than after the roughing process.

The use of the smoothing stone comes next. This is a quarried stone, turned down to 4 in. thick and about 30 in. in diameter, and mounted to revolve horizontally. It must run absolutely true and even without vibration, otherwise a great deal of breakage would result. The glass is handled on this stone in the same manner as on the roughing mill, with the result that a hazy appearance replaces the ground effect, but the bevelled part is not yet transparent. For smoothing the bevel of plates of intricate pattern a conical smoothing stone is used. The plate next passes to the "white wheel," a large solid wheel made of specially selected white wood, and set to revolve vertically. It is 3 in. thick and from 2 ft. to 3 ft. in diameter. The revolving surface is fed mechanically at the will of the operator with a mixture of ground pumicestone and water, and it causes the bevel to become clear and transparent. For the finishing polish that gives the bevel its lustre, a polishing wheel or buffer is used; this also is a wooden wheel, 3 in. thick and 24 in. in diameter, and revolving vertically, but the outer rim or working edge is covered with felt, 2 in. or 3 in. thick, and charged with rouge, the use of which ensures a finishing polish of the highest degree of perfection.

It will be obvious from the above that if a long, tedious job is not objected to, the whole of the work of glass bevelling may be done by hand, or, at any rate, with the help of simple machines the rigging up of which should not present any great difficulty. Suitable grinding and polishing materials are sharp sand; coarse, medium, and fine emery; pumice, tripoli, or putty powder and rouge.

Stencil Cutting and Stencilling

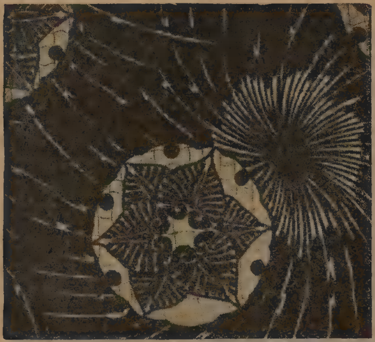


Fig. 1.—Three Examples of Japanese Stencils

STENCILLING is a mechanical method of reproducing patterns in which the design or background (or portions of both) is cut out of a thin sheet of metal or card, the cut-out plate being laid on the surface to be decorated and the pattern reproduced by dabbing colour through the perforations, thus giving a reproduction underneath. Either oil or water colour can be employed for stencilling, and, in one particular branch, dyes are used, these being sprayed on the work, this method being useful for the enrichment of textiles, such as velvet or plush, where the surface of the material is of such a nature that opaque applied colour would be inappropriate.

Stencilling is employed very extensively in house decoration for friezes, walls, panel decoration, etc., and also for lettered signs and for marking packing cases; and very largely indeed for decorating textiles, for such items as portières and hangings, tablecloths, cushion squares, and similar things.

The Japanese artists are the greatest adepts in the art, some of their stencil cutting being marvellous in its minuteness. Many of their patterns are so delicate that they adopt the method of cutting two sheets at one operation, and gumming together with a network of fine hair between that gives just sufficient strength to hold the forms together. In the examples shown

Fig. 2.—Sharpening Stencil-cutting Knife

in Fig. 1, which are reproductions of photographs of actual stencil plates, the network of hair can be clearly seen.

Tools.—One of the advantages of stencilling is that but few appliances are necessary. A good penknife with the blade ground down to a fine cutting point A (Fig. 3) is the chief requisite. The sharpening is a most important process; upon it the success of the cutting largely depends. As the cutting is executed upon a sheet of glass or zinc, which soon dulls the blade, an oilstone E is an essential item of the stenciller's equipment. In sharpening, the blade is held almost flat on the stone, which is lubricated, for preference, with olive oil, the position for holding being shown in Fig. 2, the point being rubbed backwards and forwards, and special pains being taken to observe that the end of the blade is in contact with the stone.

A sheet of plate-glass or zinc is the best for cutting upon, as the surface of a millboard or drawing-board becomes badly cut after a little use, and this is liable to cause the strokes of the knife to deviate. It is true economy to use the glass or zinc cutting plate.

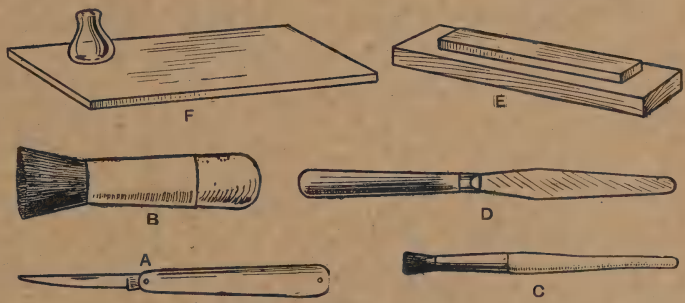


Fig. 3.—Stencilling and Stencil-cutting Tools, etc.

Stencil brushes B and C, Fig. 3 are of round form, and short and stubby; they are usually of hog-hair, with white-wood handles. Very convenient sized ones for general use are Nos. 5 and 6; the small ones should only be used for the smallest work, for much greater uniformity is obtainable with a large brush, and the work naturally takes very much less time. Stencil brushes are sometimes bound up (bridled) a short distance from the ferrule, when they are new, in the same way as painters' brushes, as in this way they last longer, and the short hairs are an advantage. The brushes require to be well kept. If, after working, they are left caked with colour for any period, they may be spoilt for future use. They require to be well washed, after using, in warm water with soap, scrubbing the bristles against the

Fig. 4.—Grinding Colour

palm of the hand so that every particle of colour is removed from the interior.

For the preparation of the colours there will be necessary a palette knife D (Fig. 3), a slab of plate-glass and a muller F for mixing up the colours. For large work, where some amount of colour will be necessary, a large mixing knife should be obtained. The glass muller is for grinding the colour upon the slab (Fig. 4). The prepared colours sold in tubes do not require grinding, and are the most convenient to employ for small work, but a great economy may be effected where much colour is needed by obtaining the colours in powder form from an oil-shop and grinding up with water or oil according to requirements. These colours are usually not ground very fine, and need to be ground after mixing up by rubbing over the glass rapidly with the muller with a circular motion, spreading out the colour a little at a time and taking care that all the colour comes between the muller and the glass. This operation is illustrated in Fig. 4.

Fig. 5.—Three Stencil Patterns

Fig. 7A

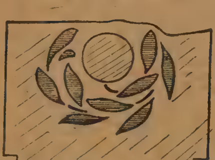


Fig. 6.—Plate with Register Cuts

Fig. 7

Figs. 7 and 7A.—Panel Stencil and Separate Colour Plate

Material for Stencil Plates.—The special paper sold for cutting out stencil plates is semi-transparent and of a yellowish colour. It is tough and waterproof. Best quality cartridge paper will serve quite well for the purpose, and bristol-board is an admirable material, but much more expensive. Plates cut from paper or card that is not waterproofed in its manufacture require an after treatment with some liquid that will render them non-absorbent, or they soon become sodden with paint, in which condition the manipulation of the brush damages them. For this purpose, french-polish can be highly recommended, it stiffening the paper and effectively preserving it, the plate being given a couple of coats on each side. For large plates, ordinary tar makes a good waterproofing material.

Patterns for Stencilling.—Fig. 5 illustrates three typical stencil patterns quite within the amateur's scope. A brief study of these designs will exhibit the fact that every mass is disconnected with the neighbouring ones, but leaving the background sufficiently connected together that, when the pattern parts are cut away, no portion of the background becomes detached. In producing this result satisfactorily lies the whole art of preparing a good stencil plate. Sufficient ties are left so that inner portions of the design are well supported. In the case of a leaf stalk, for instance (see A, Fig. 5), it will be obvious that were it carried right up to the vein, which should actually be stopped off a little short of the other end of the leaf, the vein would

become separated when the leaf was cut out. This will be even more apparent in the case of the narrow background space between the lower part of the stalks of

A

B

Fig 8.—Designs Formed by Patterns Shown by Fig. 5

the flower, which would become quite detached were it not for the narrow connecting strips in the centre and at each end. These ties are a most essential part of a stencil plate; they tend to impart to stencilling a special character just as lead lines do to a stained-glass window; therefore, their inclusion should not be considered a failing in the design. Sufficient of these must be introduced to make a strong plate, and one that will not become quickly broken. If, after cutting out a particular design, any portion of it is loose, and insufficiently attached to the surrounding parts, extra ties can be added by securing narrow strips of paper across the weak parts with fish-glue.

Each separate colour in a stencil design requires a separate plate; thus, supposing the pattern under consideration (A, Fig. 5) is intended to be executed in two colours, say pink and green, the green portion—consisting of the stalks and leaves—would be cut in one plate, and the flower in another, the size of each plate being identical, and the position that the details occupy the same in each case, so that a slight mark made on the surface that is being stencilled, where the corners of the first plate come, will form a correct guide for laying the next plate. A good plan for ensuring plates to register correctly, where a number is used, is to make a cross at each corner of the first drawing from which the various parts are traced, and then to trace this off in each case, the plates being cut at the corners as shown in Fig. 6, a mark being made on the surface to be decorated, guided by the cut in the first plate, thus giving the position for the succeeding ones. The necessity for employing separate plates for different colours lies in the fact that, in the case of portions of the designs that are close to one another, it is practically impossible to stencil one portion without some of the colour passing through the adjoining openings. When, however, a portion in one colour is sufficiently separated from that of another colour, it is quite practicable to stencil the two portions with one plate, thus saving time and trouble. Also, in the case of large patterns with just minor details in one particular colour, it is not necessary to cut a plate covering the whole, but a small plate can be prepared, registering

Fig. 9.—Using Stencil-cutting Knife

its position by cutting perforations that consist of details of the main design, so that the position can be readily obtained.

Fig. 7 shows a panel design, in which it is assumed the central device is in a different colour from the rest, the register

holes in the plate (Fig. 7A) consisting of four leaves of the main pattern as shown.

Fig. 8 gives two suggestions showing how simple patterns, such as those

Fig. 10.—Plate Cut Out

shown by Fig. 5, can, by repetition, be made to form an effective decoration for such items as a cushion square or a small tablecloth, while many other arrangements of similar simple forms will no doubt instinctively suggest themselves to the reader.

Preparing the Stencil Plate.—In the first instance, a full-size drawing is made of the pattern required to be stencilled, with the ties or connecting strips clearly defined. Then all the parts in one colour are traced off and transferred to the card from which the plate is to be made. Then the cutting out of the form is proceeded with, this operation being illustrated in Fig. 9, the complete pattern being, in this case, cut in one plate. Press the sheet flat down to the glass or zinc plate with the left hand, holding the knife in the other in very much the same way as a pen or pencil would be held, but with the little finger resting on the work as shown, to steady the blade in cutting, and to obviate slips as far as possible. The point of the blade must be extremely sharp, so that a stroke with medium pressure will make a clean cut through the sheet. A dull point results in a jagged cut with tears, and as the glass soon dulls the blade the oilstone will be in constant requisition. As a rule, it is best to cut the smaller details out first, leaving the larger ones, which weaken the plate the most, until last, thus obviating, as far as possible, breakage during cutting.

Slips in cutting and broken ties can be repaired by fragments of paper attached with fish-glue, cutting the damaged part out afresh when the glue has dried.

Fig. 10 gives the appearance of the cut-out plate at this stage.

The next process is the waterproofing of the plate, unless, of course, the proper stencil paper has been used, when this will not be necessary. To render cartridge and other papers employed for stencil plates impervious to water, lay them flat upon two or three thicknesses of newspaper and brush over freely with french-polish until the paper is saturated. Leave for a while to dry; then turn over and treat the back similarly. For a stencil plate that will have much wear, two or three coats should be given, for the polish toughens the paper and renders it much less liable to damage, and it is worth one's while to spend a little longer time upon it to obtain the maximum of strength in its wearing qualities.

STENCILLING IN OIL COLOUR

Such articles as cushion squares, hangings, etc., can be suitably stencilled in the oil colours sold in tubes. Very artistic

Fig. 11.—Using Stencilling Brush

results are producible by employing coarse textured stuffs such as crash or canvas, which are now obtainable in a wide range of shades. An agreeable harmony in the colouring should be striven for in

such things, rather than bold contrasts. In proceeding with such patterns as shown by A (Fig. 8), after the square has been cut, fold the material diagonally; the creases will then serve as a guide for laying the plate. The position of the details must always be carefully set out in this way, or by marking with chalk in the first instance. Now pin the material to a large board, or a flat table, and lay the stencil plate in position on one corner. It is best to pin it in one or two places to prevent it slipping; then the stencilling may be proceeded with. The worker should provide himself with some flake-white ground in oil, and some ordinary tube colours, the shades that are decided upon being mixed up before starting. Little or no medium should be used, as the best results may be obtained by employing the paint thickly, as by adopting this system the colour is much less liable to work underneath the plate, and thus impart a ragged edge to the forms. When ready to begin stencilling, dip sparingly into the paint, and dab the brush two or three times on the slab to distribute the colour equally among the bristles of the brush. Then hold the plate down with the left hand, as illustrated in Fig. 11, and apply the brush to the open parts of the stencil with a gentle dabbing action until the material not covered by

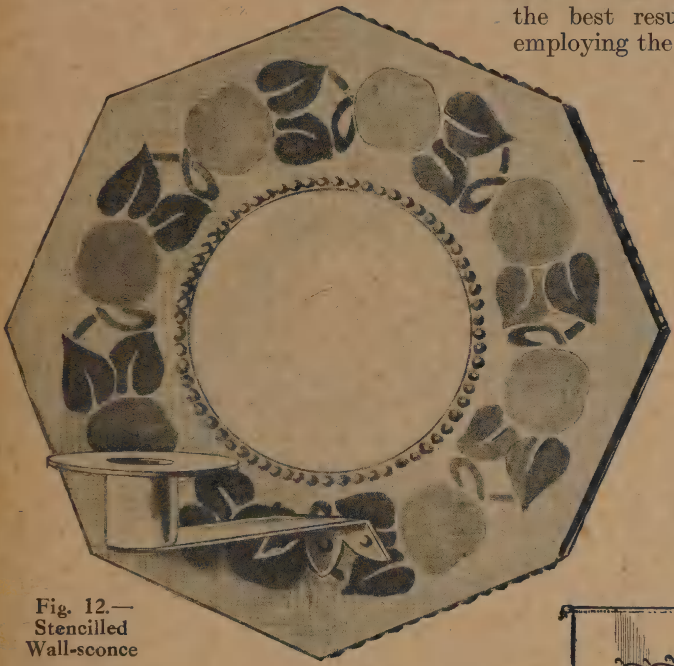


Fig. 12.—Stencilled Wall-sconce

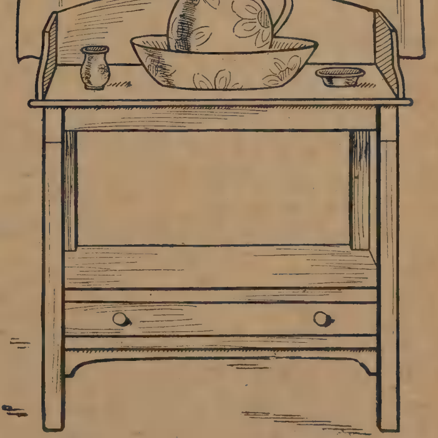


Fig. 13.—Splasher for Washstand

the plate has received an equally distributed coat of colour.

The chief fault with beginners is to apply too much colour at a time, the surplus working underneath the plate and producing ragged and unequal shapes. The brush should be only slightly moistened with colour, the depth of tone being built up by two or three applications ; it takes a little longer this way, but it is the only method by which the clean-cut, well-defined forms of a perfect stencil can be produced. Do not smear or brush the paint on ; the brush should be always held at a right angle with the face of the work. When all the perforations have been stencilled through carefully, lift the plate off and wipe the back of it, and the other corners are then stencilled similarly.

Fig. 12 gives a design for a stencilled wall-sconce, the pattern consisting of a repetition of extremely simple forms. The octagonal back is of wood, with a circular opening in the centre, rebated at the back to receive a mirror. The border is covered with coarse canvas or some such material, secured at the edges with numerous small round-headed brass tacks. A suitable colour scheme would be a pale buff or brownish ground, with the apples in a dull red, leaves green, and stalks of a similar colour but darker in shade than the ground.

A splasher for a washstand, also for stencilling in oil colour, is given in Fig. 13, the pattern on a larger scale being illustrated by A (Fig. 13). If stencilled in bright greens, with blue and reddish brown upon a pink ground, the swan being white, a particularly happy scheme could be produced ; but, of course, one must be guided in the choice of colour very largely by the scheme of the surrounding objects.

Fig. 15.—Spraying Device

Stencilling on Wood.—This process is extremely useful for the decoration of door-panels for cabinets, etc. While not being on a level with inlay, it is a ready means of introducing artistic ornamentation at a minimum of expenditure and labour. Fig. 14 shows a simple cabinet with such panels included, the pattern of the ornamentation being given by A (Fig. 14). Old panels can be re-painted, and fresh ones substituted of three-ply, the wood being sized or otherwise prepared to receive the stencilling, the colour being in some agreeable tone to harmonise with the surrounding woodwork.

Fig. 14.—Stencilled Cabinet Pattern

Spray Stencilling.—With the invention of the air-brush, stencil work was given an added impetus, it being possible to turn out work with this appliance in an astonishingly short time ; also, the surfaces of such delicate materials as silk and plush are not injured by its use, as is the case in stencilling with a

brush, and do not lose their original texture. Water dyes can be employed with considerable effect, the colours procurable being richer in tone than ordinary paints. It is possible to produce air-brush effects by the use of an ordinary spray of the type shown by Fig. 15, which is procurable at most chemists at the cost of a shilling or so. This type of diffuser gives a much finer spray than those used for scent; it consists of a glass bottle fitted with an indiarubber cork, through which passes a vaporiser connected with an indiarubber tube with two bulbs, as shown.

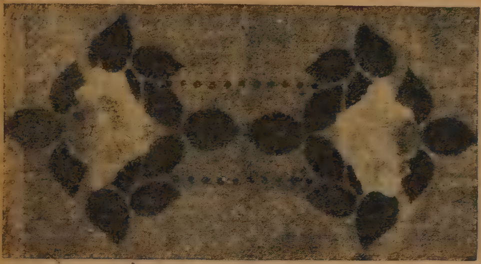


Fig. 17.—Stencilling with Spray

Fig. 16.—Three Examples of Spray Stencilling

Fig. 16 gives three examples of spray stencilling upon velvet, from which it will be seen that the results obtained are somewhat softer than the ordinary stencilling. The plates are prepared in exactly the same way, a different one being necessary for each colour in the work. The plate is pinned to the material, which is in the first place fastened to a board, and which is at an angle during the actual stencilling, as shown in Fig. 17. Aniline dyes (soluble in water), very suitable for the work, are procurable in numerous shades, made up in packets at threepence or so each. They only require mixing with water to the required depth of tone. It is better to mix up a little of the dye first, and spray it upon a piece of spare material, and then *dry it* to see the result, before proceeding to spray the finished work. Having obtained the colour required, half fill the spray bottle with it. Well inflate the larger bulb by holding the finger over the nozzle, to obtain a sufficiently forcible jet of air to make a fine spray from the start. Then remove the finger and spray equally over the open parts of the stencil plate holding the diffuser about two feet from the work, and working the bulb the whole time. Fig. 17 shows the spraying process, which is continued until sufficient depth is obtained upon the material. When this has been done, the plate is carefully removed, and the dye allowed to dry and the spraying of the next colour proceeded with. It is a convenience to have several bottles, one for each colour, which the cork of the diffuser

fits, so that it is not necessary to wash the one bottle out after each spraying.

The best method to adopt when great depth of tone is required, is to spray the

Fig. 18.—Stencilled Table-cover

work two or three times, allowing each coat to dry off between each spraying, rather than to endeavour to obtain a great depth of tone at one operation, as the dye is somewhat liable to run into little globules if sprayed much at a time; by such a case they can be removed with blotting-paper.

Fig. 18 is a simple design for an occasional-table cover in spray stencilling, the patterns of the stencilling being given by A (Fig. 18). This very simple design is one that a novice could very well execute as an experimental piece.

Stencilled Monograms and Lettering.—Stencilling is a particularly suitable process for initialling table linen and household stuffs with indelible marking-ink. The initial or monogram, however, requires to be most delicately cut, and being necessarily on an extremely small scale, it is wise to employ very simple forms in the design. Fig. 19 shows two sets of initials, each with a slight amount of ornamentation, that would not offer great difficulty in the cutting. Other initials could be similarly treated, the pattern being accurately set out on a piece of bristol-board, with sufficient ties in the design to give a strong plate. A steel knitting-needle ground flat, with a sharp end, and set in a small holder, gives a cutting tool that will not injure the most delicate forms. The cutting must be very accurate, as a ragged, uneven line will be most noticeable in such small forms. The marking-ink is lightly dabbed on with a slightly moistened brush. It must be borne in mind that too much ink on the brush will cause it to work under the edges of the plate, and cause a disfiguring smear. Only just enough should be on the brush as will cause a pale streak when drawn across the hand. Stencilled letters for signs, marking cases, etc., are easy to cut, due allowance being made for the ties previously alluded to. Fig. 20 shows how these are generally introduced, further description being unnecessary.

Stencilled Wall Decoration.—Stencilling upon walls is usually done upon a distempered ground, although there is no reason why plain paper should not be decorated by this process. The most usual method, and in many ways the best, is to employ a plain wall cover-

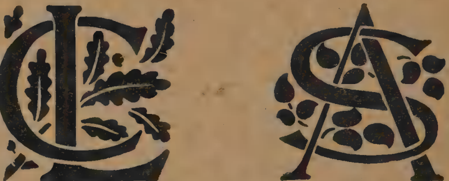


Fig. 19.—Initials for Stencilling

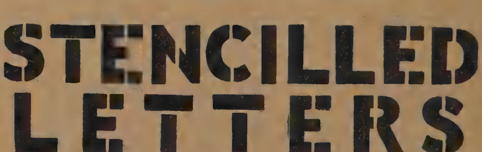


Fig. 20.—Plain Letters for Stencilling

ing, either papered or distempered with a hand-stencilled frieze above; this system has much to recommend it; plain walls are much superior to over-elaborated ones; they show up to much better advantage the pictures and furnishings of a

room, and if a nice artistic shade is selected, one could wish for nothing better.

Fig. 21 illustrates a simple treatment

Fig 21.—Plain Wall with Stencilled Frieze

that would be especially suitable for a room of fair height. The wall space, in this case, is divided by a picture rail giving a frieze of from 12 in. to 18 in. in depth. This is stencilled at intervals with a simple conventional sprig pattern. In this way a decorative scheme can be evolved with very little labour, the design being formed by the repetition of one single unit. In the pattern given in Fig. 22 the wall surface is stencilled with a simple floral diaper with a continuous frieze. This latter scheme will be found especially suitable for a large room, the pattern amply relieving the bareness of a large uncovered wall surface. A good plan to adopt in certain cases is to employ a combination of distemper and paper, by dividing off the lower part of the wall to form a dado, and use for this one of the papers expressly designed for the purpose, then to stencil the upper part with a simple repeating pattern. This system has one great advantage: dado papers are washable, and have excellent wearing qualities.

Stencilled work on walls may be in either water-colour or oil. The cost of water-colour stencilling is trifling, as powder colours, size, water, and brushes are all that are required. Its one disadvantage is the fact that it cannot be washed, and, as washable distempers are now procurable quite cheaply, it repays one in many cases to distemper the walls in a washable distemper, and stencil the pattern in oil colour. An amateur can quite easily distemper a wall in water-colour distemper. The first procedure is to clean off the old paper and then brush over with a weak solution of size. Then put several large lumps of whitening into a pail, allowing it to soak for some hours, and then beat up to form a thick cream. Melt in another vessel some size, and then add to the whitening, putting in the colouring matter to make up the requisite shade, the whole to form a liquid mixture like thin cream. Leave for a day, when it will be in the form of a thin jelly, and it is best applied in this state, in the ordinary way, with a whitewash brush.

Distemper colour dries several shades lighter than when first applied, and due allowance must be made for this in the mixing. Prussian green, chrome yellow, raw umber, indigo, light red, yellow ochre,

Fig. 22.—Stencilled Wall Decoration

and black will mix practically every shade, the depth of tone being regulated by the amount mixed with the whitening. The choice of colour, of course, rests with the worker, but as a general rule, pale greens, grey blues, red browns and flesh

tints are the best. Figs. 23 to 25 give the patterns of the stencils for the design given in Figs. 21 and 22; they are enlarged up and the stencils cut in the usual way, with a different plate for each colour, after the scheme has been decided upon by experiment.

An important item is the spacing out of the units of the pattern on the walls, the position being carefully indicated by chalk lines. A distance of about 2 ft. to 3 ft. between would be about the amount in the case of the frieze pattern given in Fig. 21. Long lines that may be required to obtain the position of the repeats on the actual wall surface can be best made by first setting out equal distances along the top and bottom of the wall, and then, with assistance, holding a chalked string to the points, at the necessary angle. By stretching the string tightly, and pulling it up and allowing it to snap back against the wall, a chalked line will result that will serve as a guide for finding the position of the units.

Favourite themes for treatment in stencilling are landscape subjects, these being often employed as a frieze decoration. Figs. 26 to 28 give three simple suggestions for such subjects that an amateur could be expected to produce; although in commercial work a very much greater degree of realism is obtained by working numerous tones one upon the other to obtain a richness of effect in shading and relief.

Fig. 26

Fig. 27

Fig. 28

Fig. 23

Fig. 25

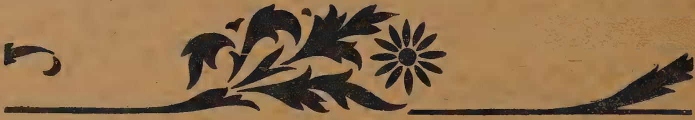


Fig. 24

Figs. 23 to 25.—Stencilled Patterns for Wall Decoration

Figs. 26 to 28.—Stencilled Landscape Views

Stone Cutting and Polishing

Various Stones and Where to Find Them.—Of the stones to be found on the seashore that repay the work of cutting and polishing are various kinds of quartz or silica; other and softer stones that make interesting specimens when shaped and polished are serpentine, some forms of felspar, granites, and limestones, particularly those containing fossil remains, like the "madrepore" rocks, generally classified under the general term "marble." Many "pebbles" may be angular in shape, having not long been washed out of the cliff by the action of the tide, not sufficient time having elapsed for the water to have cut and polished them in its own crude way.

Pebbles showing various grades of transparency or translucency are almost always worth securing. They may prove to be agates, carnelians, jasper, or the various forms of chalcedony. On certain shores, and indeed inland, as amongst the Scottish mountains, cairngorms may be found, and less commonly amethyst. All the stones enumerated are forms of silica closely related to the common flint.

The happy hunting-grounds of the pebble searcher are pretty evenly distributed round our coasts. A few may be named for the benefit of those not well acquainted with their position and possibilities. Perhaps the South Coast is the most productive. Brighton provides "landscape" pebbles; Deal, agates of kinds. Ramsgate, Bognor, Eastbourne, and Chesil Beach are worth while searching for their various specialities. The coasts of the Isle of Wight, Plymouth Hoe, and the whole of the shore lines of Cornwall and North Devon abound with good specimens. South Devon produces the madrepores. On the East Coast, Cromer, Harwich, Felixstowe and Aldeburgh are good hunting grounds. At the last-named many ambers turn up after heavy winter storms, and are secured by local fishermen and others before the summer visitors arrive. Filey yields transparent siliceous pebbles. The East of Scotland produces jaspers. In the West the Welsh coast yields good specimens, Aberystwith having a reputation for agates and jaspers.

A visit to a mineralogical museum is useful to the novice, as there he may become acquainted with the general appearance of the rough specimens, seeing them side by side with similar specimens polished. He will find exhibits of "moss," "landscape," "fortification" and other agates, and see just why they have acquired their names, as well as learning to recognise them in the rough.

The only necessary equipment for the pebble searcher is a file and a bag in which to bring home his specimens, though even these may be dispensed with if a knife be carried, and the searcher has ample pocket accommodation. The file is to test the hardness of the pebbles, so as to be able to differentiate a piece of agate, say, from a softer stone like marble.

Amber and jet, which are found sparingly on the coasts, hardly should be termed stones; but they repay for working and polishing, and on account of their softness are easy to manipulate. Both may be cut with a saw, and shaped with a file. Polishing may be done with powdered charcoal and soft soap, applied in liquid form with a flannel and elbow grease.

Polishing the Harder Stone Pebbles in a Lathe.—The writer will first deal with pebbles of the harder stones which it may be desired to polish on one face, no actual cutting being done. Pebbles of slight convexity so treated may be used

Fig. 1.—Pebble, with Handle, Ready for Polishing

effectively in the decoration of cabinet work, or for inlaying in decorated copper or pewter. If this application be contemplated, it is well when collecting to endeavour to match the pebbles in pairs, or groups of equal size and shape, which is not difficult where the stones are in abundance, as it thereby facilitates the subsequent grouping when they are used as decoration.

It is often recommended to do the rough grinding on a grindstone or sandstone slab. The writer does not favour that method, because it tends rather to produce a set of facets than a smoothly curved surface. It is much better to work with a good abrasive powder, of which the best is carborundum. This may be purchased quite cheaply in various grades of fineness. That marked "150" serves every purpose. The method of use will depend on the worker's equipment in other directions. If he has a lathe he may chuck his stone, first cementing it to a cone of wood and attaching the latter to the faceplate, which may be done with Croid glue. He may then apply the abrasive powder wet with a piece of soft wood dished to fit the stone surface, or with a block of lead with a hollow cast in one face.

On the other hand, the converse process may be adopted of chucking a hollowed wood block to carry the abrasive, and applying the stone to its rotating surface. In the latter alternative the stone must be mounted on the end of a short handle, by cementing it thereto in the manner shown by Fig. 1. There is little to choose, on the score of convenience and efficiency, between the two methods of working.

For cement, sealing-wax will serve; but a more reliable material is a mixture of Burgundy pitch, resin and shellac, with the addition of a small proportion of beeswax according to season, the lower the temperature the more the quantity. The proportions are 8, 4 and 2 by weight for the three first-named.

It is important to use care, so that the abrasive powder does not get into the mandrel bearings of the lathe, or a good lathe will be ruined. Hence if the worker seriously intends to go in for stone polishing, it is better for him to provide himself with a lapidary's lathe.

Having ground the pebble to a smooth dead surface free from pits, scratches and other blemishes, the process may be carried further by a second or fine grinding with a new tool, using washed flour emery, made by mixing the finest emery-powder with water, well shaking the mixture, and allowing it to settle for a few minutes, and then pouring off the liquid into a clean vessel, where the fine particles still in suspension are given time to settle. The sediment so obtained is of the finest grade, and will produce a semi-polish on the surface of the pebble when applied in the same manner as the carborundum. It should be noted that every care must be used to wash away all carborundum

residue clinging to the stone and its support before starting with the emery. Otherwise fine scratches will start into being to mar the surface produced by the emery.

Another method of fine grinding, applicable to some of the softer pebbles, is to use a piece of water-of-Ayr stone, or snake stone as it is sometimes called, applied to the rotating pebble with plenty of water.

To polish, use a felt pad tacked to a flat piece of wood by pins driven into its edges, charged with putty powder and oil, working with plenty of pressure until the polish comes and remains after the stone has been washed free of oil. For the hardest stones, and to obtain the most brilliant polish, the work should be done with washed jeweller's rouge, using as a tool a shaped block of wood coated with pitch to a thickness of at least $\frac{1}{4}$ in., and water instead of oil. As the process approaches completion the tool should be allowed to become almost dry, when a burnishing process sets in that gives the final brilliant surface to the stone. This is the method employed in the working of the glass mirrors for reflecting telescopes to the perfect state of polish that their case demands.

A Simple Polishing Spindle.—Readers who do not possess a lathe may proceed by a simpler process. The apparatus may be improvised in a few minutes. It is shown in Fig. 2. A short rod of hardwood is ferruled at one end, and a stout wire nail is driven in centrally, the head cut off, and the end filed to a blunt point. Centrally in its length is fixed a cotton reel, the central hole of which must be enlarged for the purpose. To the other end of the rod the pebble is cemented. A block of wood of convenient shape has a stout piece of brass screwed to its under surface, in which is drilled a recess to take the end of the wire nail (see A, Fig. 2), which serves to put pressure on the stone by means of the left hand whilst the rod is being rotated by the use of a bow. A hollow block B, to which the abrasive is applied, is suitably supported, and the grinding is done by a reciprocating movement of the bow. This method, or one very similar to it, is used by the native lapidaries of India.

By a little ingenuity the device may be improved by providing means for putting pressure on the rod by a weight, thus leaving the left hand free, and making the operation of grinding less fatiguing.

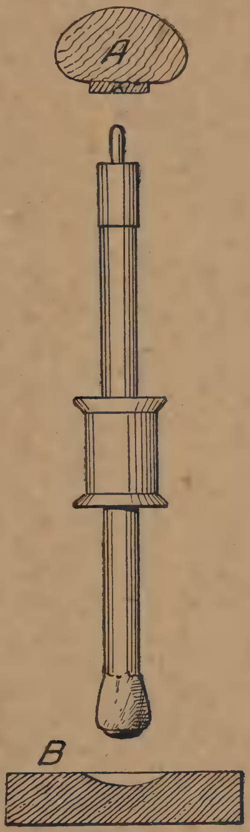


Fig. 2.—Simple Polishing Spindle

For small pebbles an archimedean drill stock might be adapted to achieve the same purpose, if the user is prepared to take the risk of injuring its mechanism by allowing the abrasive to touch it, a contingency it needs some care to avoid.

Making a Lapidary's Lathe.—For the slitting of stones, which in many cases is the only method by which their beauty may be revealed to the fullest extent, recourse must be had to the lapidary's lathe,

which actually is a very simple machine that is within the capacity of most amateur mechanics to construct for themselves.

Fig. 3 sufficiently explains the construction of a machine of the kind. A stout framework is made to support two vertical spindles, the driver and the driven. The latter is adapted for carrying a series of discs for use as slitters and laps. Motive power is supplied by turning the handle with the left hand, and a high rate of speed is attained by the large disproportion between the driving and driven pulleys.

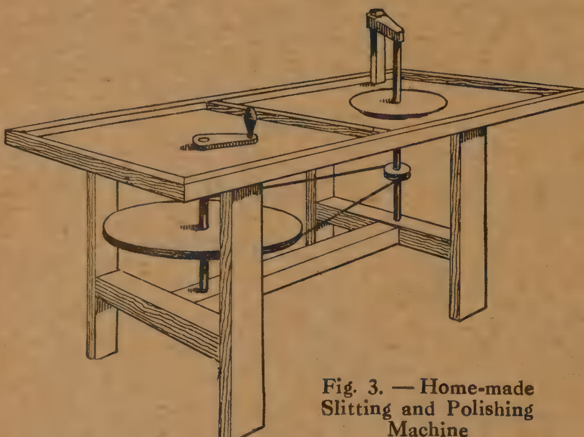


Fig. 3. — Home-made Slitting and Polishing Machine

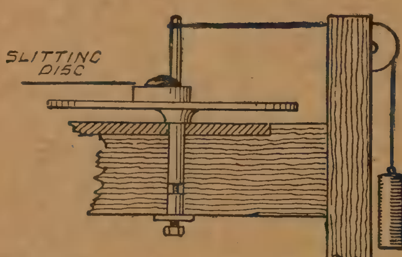


Fig. 5.—Self-acting Feed for Slitting Pebbles

A lathe built on the above general lines may easily be further elaborated so as to work with a treadle, for which Fig. 4 gives a suggestion, and there is the added advantage that the driving wheel coming into the vertical plane, the whole apparatus occupies less space. In fact, such a lathe follows the lines of the professional lapidary's tool in all essential details.

Professional lapidaries' lathes generally are fitted with a means for advancing the stone when slitting, by mechanism actuated by a weight. It consists of an iron disc mounted on a vertical spindle and capable of turning freely, on the upper surface of which near its edge is a shallow cup, into which the stones are cemented. Diametrically opposite to the cup is a post, to which is fixed a cord carrying a weight at its other end, the cord being led over a pulley on the edge of the table. The arrangement is shown in Fig. 5. This has the advantage of freeing the right hand, and by the unvarying pressure it exerts in advancing the stone in the plane of the slitting disc, it ensures a clean cut, which reduces the amount of labour in the subsequent processes of grinding and polishing. The work of cutting and polishing stones is interesting, if rather messy in some of its stages, and proficiency is soon acquired by an intelligent worker.

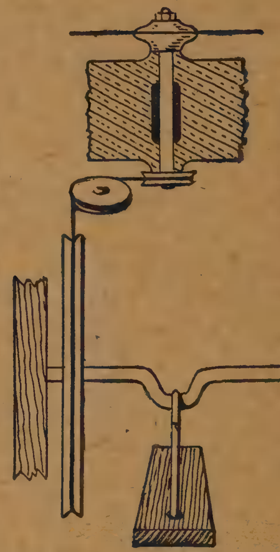


Fig. 4. — Suggested Treadle Drive for Polishing Machine

Cutting or Slitting Stones.—For slitting, that is, cutting thin sections of uni-

form thickness from a stone, a soft iron disc is employed, its edge being charged with diamond powder, a very small quantity of which is required. A minute amount of the powder is made into a paste with oil, and applied to the edge of the disc, and with a hard steel roller is pressed into the edge of the metal whilst the disc is being slowly rotated. No powder should be permitted to get on the sides of the slitter. A disc thus charged will cut through the hardest stones in a very short time. It is essential to use a suitable lubricant, that known as "oil of brick" being the best.

The stone should be cemented to a wood block of suitable height after having determined where the cut is to be made, and then it is easy to press it against the slitter with the right hand, whilst the lathe handle is worked with the left. Successive slices of predetermined thickness may be cut by adding the same thickness of wood to the bottom of the block.

In grinding and polishing in the lathe the same abrasives should be used, the work being mounted on a handle in the manner already described, and applied to the rotating surface of the lap, when the result is to be a surface capable of being so worked. The laps are usually about 8 in. in diameter, four being considered a full equipment, namely, one of beech, one of soft wood like pine, one of lead, and one of pewter. The soft-wood lap is covered with felt or cloth for polishing. The others are used with abrasive powder and oil lubricant.

For working stones of convex contour, the spindle head can be furnished with a small cup, into which the stone is bedded with cement, the abrasive being applied with a hollowed tool, as already described. The advantage of a lead or pewter lap is that the particles of abrasive become embedded in the surface of the metal, and thus give a quicker cutting action.

Precious Stones.—The cutting of the more precious stones and particularly the operations involved in faceting, call for a higher degree of skill and more elaborate machinery than the amateur is likely to possess.

Working Coral, Shell, etc.—In addition to the working of pebbles, amber and jet, like processes may be employed on coral and on various kinds of shell. The New Zealand ear shell provides a material that easily is slit into thin plates and given a high polish; when it reveals its attractive nacreous lustre and brilliant colouring to the best advantage. The slit sheets may be rubbed to a good surface on almost any type of oilstone, and polished on a felt pad with crocus composition, a kind of soap that is rubbed on the felt and leaves there sufficient of its substance to effect the polishing. Mother-of-pearl may be dealt with similarly. A further use for the slitting disc is for making sections of shells to show their internal structure, or of fossils, many of which take a high polish.

Artificially Colouring Stones.—The worker who has acquired facility in cutting and polishing will find it useful to be able to colour certain stones in a permanent way. It may not be generally known that the onyx is merely an agate in which the black portion has been coloured artificially. It is cut from an agate showing white bands in a translucent matrix. The latter being to a certain degree porous, advantage is taken of that property to introduce colouring matter into its substance in the following way. The stone after polishing is steeped for some days in oil or syrup, which penetrates to some distance into its substance, and then is boiled in dilute sulphuric acid, which has the effect of carbonising the oil or syrup, thereby producing a brown or black, according to the degree of absorption that has taken place.

Colourless chalcedony may be given a pleasing red shade by steeping it in a solution made by dissolving some iron nails in nitric acid. It is then dried and gradually heated on a hot plate until it changes to the desired colour, the iron contents being decomposed and red peroxide of iron being left in the substance of the stone. A blue colour is imparted by a similar process; but instead of heating after soaking in the iron solution, the stone is immersed in a solution of ferro-cyanide of potassium in water, the result being that prussian blue is precipitated within the stone.

Metal Turning

THIS chapter will be concerned with the practice of metal turning, the reader being assumed to have read an earlier chapter in this volume in which the lathe and accessories are described. Work held in chucks will be ignored for the time being, and a start made with the cylindrical turning and side facing of bars held between the lathe centres.

CENTERING WORK IN THE LATHE

Rough-and-ready Method. — Before turning a cylindrical bar the ends must be correctly centred. There are several methods of doing this, possibly the simplest being that in which a centre-punch is driven into approximately the centre of the material, and the work placed between the centres and spun round by hand or power. A piece of chalk is then held against the bar, and the out-of-truth portion will first touch the chalk, and so a mark will be made. Next remove the bar from the lathe, and "draw" the centre by means of a centre-punch or small cross-cut chisel (see Fig. 1). The bar runs out where the chalk mark A is seen, this portion being farthest from the centre already existing; it follows that the centre requires to be placed nearer the out-of-truth portion in order to make the bar run true. In drawing the centre, the punch must first be driven in the direction indicated, and afterwards struck vertically in order to shape correctly the centre. If on replacing the bar between the centres it still runs out of truth, the centre will have to be drawn again until the bar runs true without wobbling.

Marking Centre with V-blocks and Scribing Block.—There are several ways in which the centre can approximately be marked, instead of judging by the eye. When using large material, it is not an easy matter to gauge the centre to, say, $\frac{1}{4}$ in., so to save time it is desirable to adopt a method of marking that will ensure the centre being nearly correct. Fig. 2 indicates the method of marking out the centre by means of a scribing block. The bar is indicated at A, and is resting in the grooves of two V-blocks B and C, placed on the lathe bed. Two horizontal lines, as indicated in Fig. 3, are scratched by means of the scriber point, and the work is given a quarter of a revolution, and two more lines made at right angles to those already made. The centre of the square enclosed by the lines is the centre of the material, and the centre-punch is driven in at this point.

Ascertaining Centre with Odd-leg Callipers.—An easy way of obtaining the centre is by using "odd-legs" or hermaphrodite callipers (Fig. 4). The manner of using is indicated by Fig. 5, A being the bar, and B the callipers. The odd-legs are opened a distance approximately equal to half the diameter of the bar, and the bent leg is placed on the periphery of the material, as indicated at C. Four lines are then scratched on the end of the bar, the odd-legs being moved

to four different positions. If the callipers are set nearly correct, the lines will be drawn as shown in Fig. 6; if the instrument is set with the scriber point short of the centre, the result will be as in Fig. 7; and if the point is set wider than the centre the resultant lines will be as shown in Fig. 8. However, this does not make any difference to the result obtained, beyond perhaps marking a large square, and increasing the liability of incorrectly locating the centre, owing to the worker having to judge by the eye the centre of the space enclosed by the lines. An effort should therefore be made to scratch the lines as near to the centre of the bar as possible.

Marking Centre with Centre Callipers.—The use of centre callipers (Fig. 9) obviates the necessity of using either odd-legs or a scribing block and **V**-blocks when finding the centre of a bar, and enables the worker instantaneously to find the approximate centre, within the capacity of the instrument. The method of using is shown by Fig. 10, the bar being held in one hand and the callipers in the other; the legs of the tool are opened, so that both of them touch the outside of the bar, and the scribing point touches the

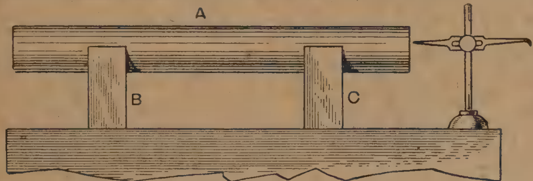


Fig. 2.—Method of Finding Centre of Bar by Means of Scribing Block

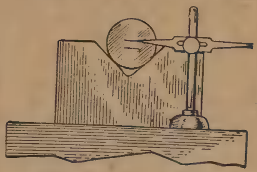


Fig. 3.—End View

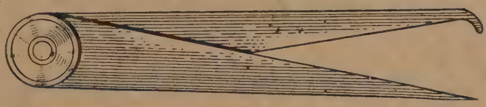


Fig. 4.—Hermaphrodite Callipers or Odd Legs

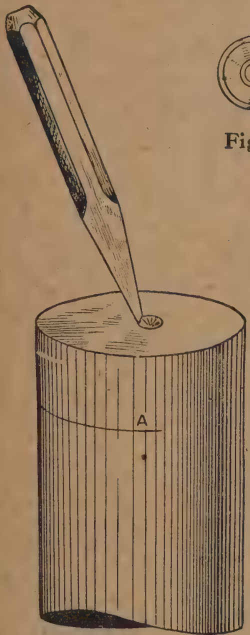


Fig. 1.—Method of Drawing the Centre


Fig. 6.—Centre Lines Drawn Approximately Correct

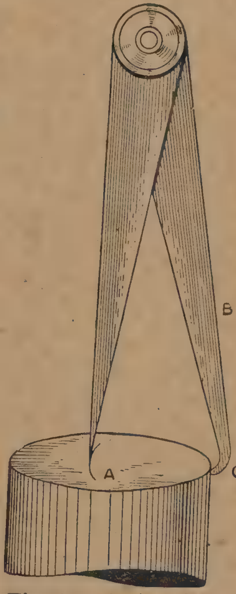


Fig. 5.—Finding Centre of Bar with Hermaphrodite Callipers

material. Two lines are then drawn at right angles as shown, and the intersection of these lines is the centre of the bar; the point of a centre-punch can then be driven in.

If it is desired to find the centre of a piece of material that has an irregular-shaped end, such as a bolt or as the bar shown by Fig. 11, it can easily be done by drawing farther back the scribing point which is adjustable, in order to allow the calliper legs to touch the round portion.

Fig. 7.—Example of Centre Lines Incorrectly Marked

Fig. 8.—Further Example of Centre Lines Incorrectly Marked

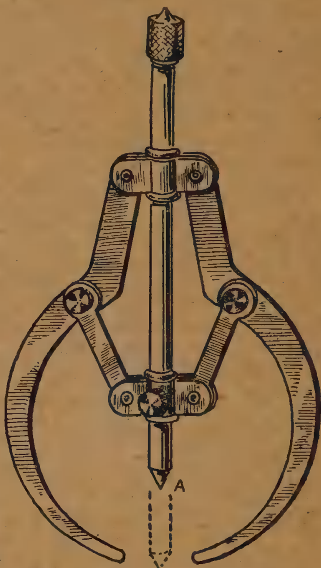


Fig. 9.—Centre Callipers for Marking Approximate Centre of a Round Bar

Fig. 11.—Marking-out Bolt Head with Centre Callipers

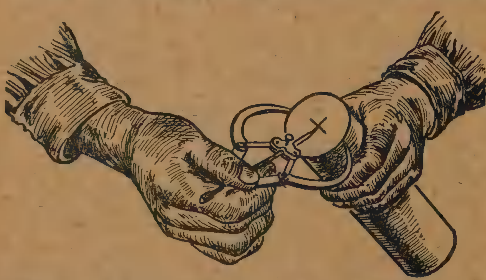


Fig. 10.—Marking Centre of a Round Bar with Centre Callipers

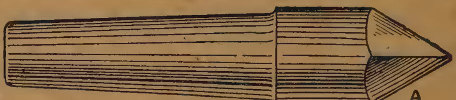


Fig. 12.—Old Form of Square-centre

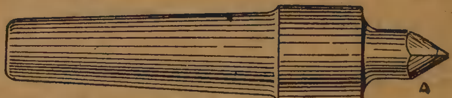


Fig. 13.—Improved Form of Square-centre

Countersinking and Drilling the Centre.—After the centre dots are correctly located, whatever the means

employed may have been, a square-centre (Fig. 12) is inserted in the tailstock, a carrier fixed on the bar, and the work then inserted between the lathe centres,

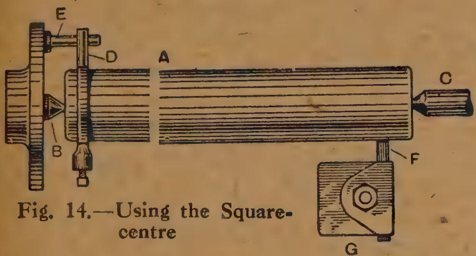


Fig. 14.—Using the Square-centre

the square-centre being fixed in the tailstock. Four flats are next ground at A (two are shown) in order to make four sharp corners, which act as cutting, or, rather, scraping, edges. The work is revolved in the ordinary way, and the square-centre fed in by means of the tailstock handwheel. This causes the square-centre to advance and scrape out a smoothly finished countersink, in which the ordinary tailstock centre is afterwards placed.

As the square-centre wears blunt, the flats are re-ground on the grindstone, which is rather a troublesome operation; in order to lessen this, a square-centre of the shape shown by Fig. 13 is sometimes used. The end A is turned down to a small diameter, thus reducing the amount of material that has to be ground away when sharpening.

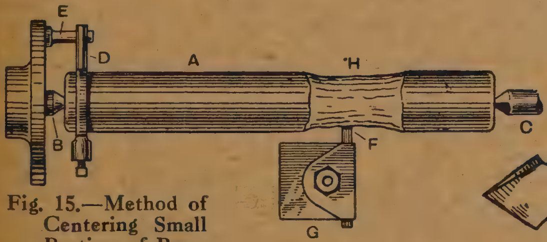


Fig. 15.—Method of Centering Small Portion of Bar

If the centre-punch recess has been deeply and carefully made, the bar should not run out of truth during the centering operation, or change the position of the periphery in relation to the centre.

A method sometimes adopted by turners when square-centering is shown by Fig. 14. The work A is placed between the live centre B and the dead centre C, being driven by means of the carrier D

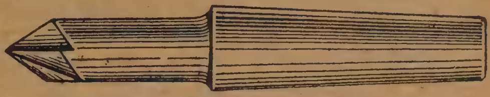


Fig. 16.—Drill for Centering Machine

and driving pin E. Next, a piece F of brass, copper, or iron is fixed in the slide-rest tool post G, which is moved forwards by means of the cross-slide screw. The piece of brass prevents the work running out of truth during the process of centering. It frequently happens that a forged bar has very little extra material in one part, and when this is the case it is usual to set the small diameter true. The method of ensuring the true running of the small portion is shown by Fig. 15,


Fig. 17.—Combination Drill and Countersink

where the letter references are the same as in Fig. 14. The small part of the bar is shown at H, and it is important that the material should run true where the piece of brass F touches it.

After a bar is square-centred, it is the usual practice to drill a hole up the centre recess, as shown at A in Fig. 19, B indicating the centre, and C the material to be turned. The drilling of the small hole keeps the work from binding on the centre point and lessens wear, since a large area of contact


Fig. 18.—Drill for Hand Centering

reduces wear. The hole can be filled with felt soaked in oil, thus lubricating the centre. If the small hole is not drilled the finely-pointed end of a centre-punch could be utilised, striking the other end of the punch with a hand hammer.

Although the method of square-centering is here described, owing to its universal employment, the writer is of the opinion that the centering of bars in this manner

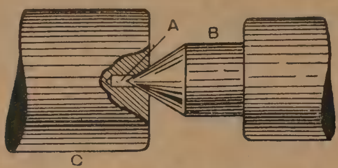


Fig. 19.—Correctly Finished Centre Recess

is a very crude proceeding, causing a great loss of time and producing an unsatisfactory centre recess.

The better and more up-to-date method of centering bars, in vogue in modern engineering shops, is to use drilling machines or centering machines having

Fig. 21.—Obtuse-angled Centre Recess

the spindles arranged horizontally, a lathe, specially adapted, answering the purpose quite well. In these machines the centre drill revolves instead of the work, which is held in a three-jaw or four-jaw self-centering chuck. The drill (Fig. 16) is first used, and followed by a combination drill and countersink of

Fig. 23.—Blunt Centre Point

the shape shown by Fig. 17. The small part of the drill cuts the small hole A (Fig. 19).

Sometimes the countersink is drilled by means of a centre drill (Fig. 18), which is held in a hand brace.

It is important that the lathe centre should fit the centre recess correctly, as shown by Fig. 19; the angle generally used is 60°, with which both the centre

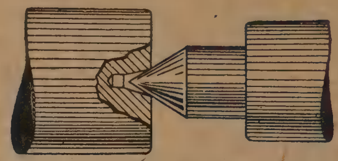


Fig. 20.—Acute-angled Centre Recess

recess and the lathe centre should agree. If the centre angle is correct and the recess is drilled at too acute an angle, the result will be as shown by Fig. 20. If the centre is correct and the recess is drilled at too obtuse an angle, the result will be as shown in Fig. 21. It is obvious that in

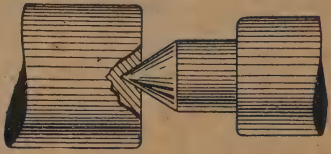


Fig. 22.—Centre Recess without Point-clearance Hole

both cases the area of contact is small, and rapid wear would take place. The centre point might break off if the bar is centred as in Fig. 21, and the material would rapidly wear as the bar revolves, causing untrue work. Work should never be revolved between the centres of a lathe if the centre recess is made as shown in

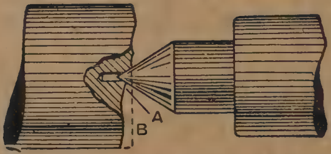


Fig. 24.—Dangerous Method of Centering

Fig. 22; this is very bad practice, and trouble would soon be caused by the heat generated by friction.

Fig. 23 shows a blunt centre. Trouble would also occur with this form of centre, and the work might be forced out of the

lathe, owing to the small distance that the centre enters the bar and the large amount of bevel, which would render easy the forcing out.

Facing Ends of Bar.—When centres have been correctly made in both ends of the bar, it is necessary, in order to ensure the bar running true after it is turned, to face up the ends so as to make them level before any of the cylindrical turning is done. If the end of the bar were of the section shown by Fig. 24, and the cylindrical turning was done without the ends being faced, the portion A of the centre recess would wear rapidly, and so cause inaccurate turning. It might also happen that the work would be torn out of the centres owing to the small amount of material at A; the dotted line B indicates the position of the end of the bar if it were level, instead of being of irregular shape, and gives an idea of the amount of material that should be present in order to produce accurate results.

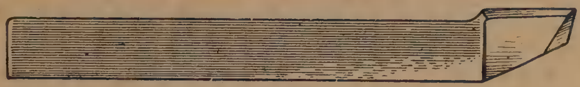


Fig. 25

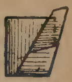


Fig. 26

Fig 27

Figs. 25 to 27.—Side-finishing or Knife Tool

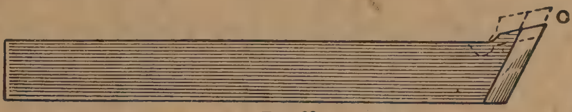


Fig. 30

Fig. 31

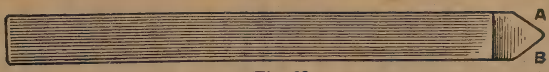


Fig. 32

Figs. 30 to 32.—Diamond-point Turning Tool

The tool used for facing up the ends of the bar is shown by Figs. 25 to 27 and is called a side-finishing or knife tool. It is clamped in the tool post as shown in Fig. 28, and fed in the direction of the arrow A while the bar is revolving. This causes the uneven end to be faced up and all irregularities to be removed. If the bar is a large one, the width of the cut taken will be limited by the length of the tool blade and the power available. Fig. 28 shows at B the amount of material removed at one setting of the tool. When sufficient metal has been cut away, the tool is advanced by means of the cross-slide screw in the direction of the arrow C, after winding the tool post back to the first starting place along the line A. When one end is faced down the required amount, the bar must be taken out of the centres, reversed, and the other end squared up.

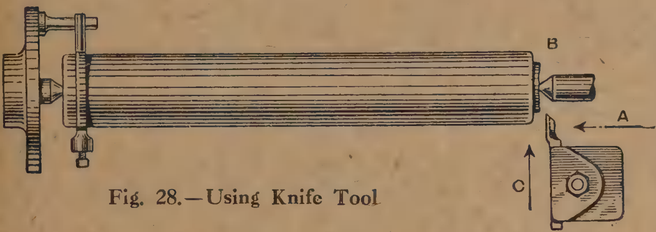


Fig. 28.—Using Knife Tool

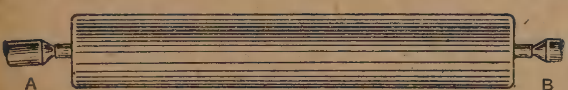


Fig. 29.—Bar with Faced-up Ends

When the ends are faced up to size, the bar will probably be as in Fig. 29, where the work is shown suspended between the centres without the driver. The ends A and B require to be chipped off with a hammer and chisel, and a fresh centre recess drilled in; this will necessitate going through the whole process of centering again. For this reason it is advisable so to arrange the job that when

the pieces are cut off a part of the centre recess remains, thus saving the trouble experienced in wholly re-centering the work.

TURNING CYLINDRICAL WORK

Having squared the ends of the bar of steel and drilled fresh centre recesses, if necessary, the work is now ready for turning "over the top"—that is, cutting to cylindrical shape. Figs. 30 to 32 show the ordinary diamond-point turning tool, the lower dotted line in Fig. 30 indicating the probable shape after grinding many times, and the upper dotted line the shape of the tool as preferred by some turners. The sloping parts A and B (Fig. 32), and the top of the tool C (Fig. 30), are ground on a stone in order to provide a cutting edge; the nose D is made obtuse or acute, as the worker desires.

If cast-iron is being turned, a very blunt nose is necessary, and for mild steel a finer point will be required.

When fixing the tool in the tool post, it should only be allowed to project a very small amount, as shown in Fig. 33, this position affording rigid support to the tool and minimising the liability to chatter; the shank of the tool should be set in line with the side of the tool post.

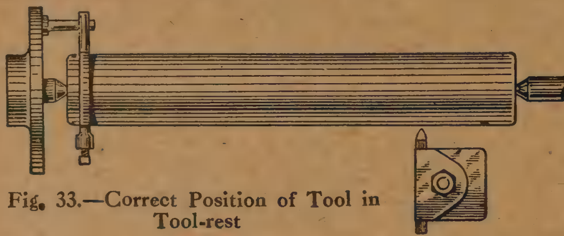


Fig. 33.—Correct Position of Tool in Tool-rest

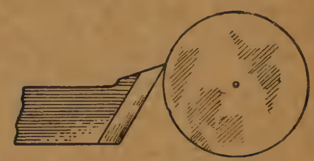


Fig. 34.—Turning Tool at Correct Height

Fig. 36.—Turning Tool too Low

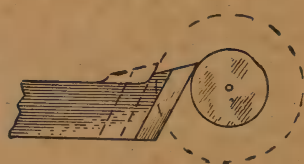


Fig. 35.—Turning Tool too High

Fig. 38.—Turning Tool with Its Cutting Edge Ground Off

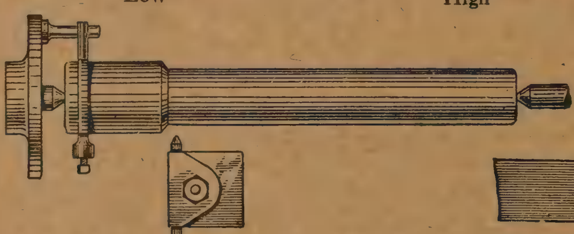


Fig. 39.—Bar Partly Turned

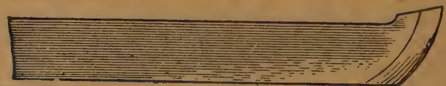


Fig. 37.—Diamond-pointed Tool Spoilt by Incorrect Grinding

Setting Height of Tool.—The height at which the tool should be set is governed by the shape of the tool, the shape here considered being that shown by Figs. 30 to 32.

The turning tool requires to be set at a different height for nearly every diameter of material, and this should be remembered when setting. It frequently happens that as the diameter of the bar is reduced by taking several cuts over the top, the position of the tool must be altered. In ordinary turning, however,

the work is so arranged that only a small amount of material has to be removed.

Fig. 34 represents an end view of a bar with the tool placed in a good position for cutting, whereas in Fig. 35 the tool is placed too high for cutting the bar after reduction, this resulting in the material touching the tool just below the point.

If turning is attempted with a tool placed as in Fig. 36 the work may be forced out of the centres, the tool being placed too low for effective work, and damage resulting to the bar if it is turned while the tool is in the position shown.

If turning a long bar with a tool placed as indicated in Fig. 36, it is probable that a different diameter would be turned as the tool moved away from the tailstock centre. It can be seen from Fig. 35 that it is necessary to alter the height of the tool to suit the diameter of the bar. The dotted circle and tool point indicate the correct position of the tool for the large diameter, the other tool point and circle showing the impossibility of turning the small diameter with the tool placed at the same height as for the large bar.

Take care to note whether the tool alters its position when clamped down, and to pack it up, should this be necessary, with thin pieces of tin between the tool and the rest.

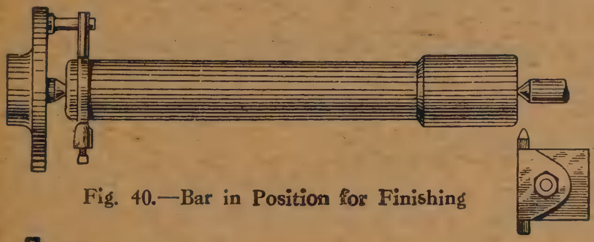


Fig. 40.—Bar in Position for Finishing

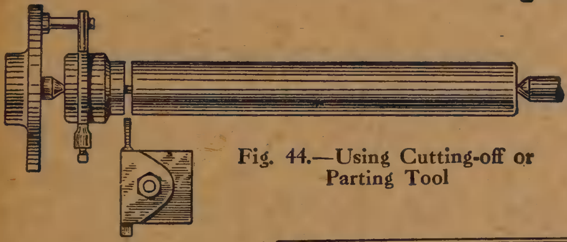


Fig. 44.—Using Cutting-off or Parting Tool

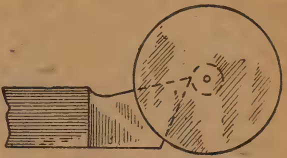


Fig. 45.—Parting Tool in Correct Position

Fig. 41

Fig. 42

Fig. 43

Figs. 41 to 43.—Cutting-off or Parting Tool

Preserving Tool Shapes in Re-grinding.—When re-grinding the tool for cylindrical turning, care must be taken that the original form is adhered to ; it is an easy matter to grind the front as shown in Fig. 37, and this renders the tool practically useless. In the desire to sharpen the cutting edges only, the tool sometimes becomes of the shape indicated ; it is important, therefore, to see that, when the tool is first sharpened, it is ground to a sharp edge. Another precaution to be observed is that the cutting point is not to be ground as in Fig. 38 ; this mistake is frequently made, and the tool cannot cut if placed in the position that it occupied before grinding.

Turning the Whole Length of a Bar.—When turning a cylinder it is usual to reduce the diameter of the bar as close up to the carrier as possible. Fig. 39 indicates a bar that has been turned only partly to the required size. The bar is then placed end-for-end (see Fig. 40), and the superfluous material removed. Now if the live or headstock centre is perfectly true the tool will correctly finish the remaining part of the bar ; but the writer does not recommend this method of

finishing plain surfaces; he prefers to turn close up to the driver, and then cut off the end with a parting tool (Figs. 41 to 43).

Using Parting Tool.—The method of using a parting or cutting-off tool is shown by Fig. 44. The tool requires setting so that it will be the correct height when cutting the smallest diameter, say, ¼ in. Fig. 45 is an end view (enlarged) of the bar being cut and the parting tool, the latter being partly shown by dotted lines. Care must be taken in feeding-in the cutting-off tool, especially when the small diameter is reached; any irregular or jerky feeding will probably result in the work being forced over the top of the tool. When grinding parting tools sufficient clearance must be allowed in the sides of the blade, as in Fig. 43, in order to prevent binding.

Taking the Finishing Cut.—It is advisable to keep a well-ground tool specially for finishing cuts, as the ordinary tool must be ground afresh when used for this purpose. The width of the tool nose will depend upon the material operated on, as previously explained. The tool must be set at a favourable height, rigidly bolted in the rest; the carrier must be carefully inspected to see if it is being strained, and plenty of soap-and-water lubricant, or "water mixture," applied to the tool. ("Water mixture" is made by dissolving special alkaline and other substances in water.)

The speed of the bar is generally increased for finishing cuts and the feed, or the amount that the tool traverses per revolution, is correspondingly reduced. However, the class of work, the length of the bar, and its rigidity are the chief factors, and experience alone is the only means of procuring reliable information concerning the speed and feed of finishing cuts.

If, when turning the diameter, it is found to taper when tested with callipers, it will be necessary to move the tailstock either towards or from the operator. If the tool cuts the bar smaller as it advances towards the headstock, the tailstock will have to be moved towards the front of the lathe; if the work is of larger diameter at the headstock end, it will be necessary to move the tailstock away from the operator. Most lathes are fitted with an adjusting screw in the tailstock, which renders the moving easy, and some tailstocks are provided with a scale, in order that the amount of movement may be noted.

Using Callipers on Turned Work.—In measuring cylindrical work with callipers it is advisable to stop the lathe before so doing, as otherwise there might be an accident; the calliper points are apt to be "seized" by the work and the callipers dragged out of the hand. Apart from this, the holding of calliper points on the bar while turning is bad practice, as the newly cut surface, being very rough, rapidly grinds the points to a peculiar shape, and thus destroys their accuracy.

The correct method of measuring a bar is to hold the callipers with the thumb inside the two legs, and practically balance it in this position. The points are then placed over the work from the back while the work is at rest. Although some turners prefer to use the callipers from the front, more accurate measurements can be obtained by measuring from the back. Considerable skill is necessary to use callipers correctly; they should not be forced over the bar, but so set that they just touch the work with both points. It is possible for an experienced worker to "feel" the difference of 1,000th of an inch (·001) by means of ordinary callipers.

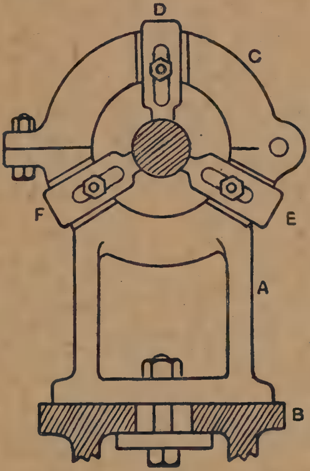
Causes that Produce Bad Results.—In the production of truly cylindrical bars there are many things that might cause bad results. Inaccurate turning may result from many causes, amongst which are: centres out of truth, incorrect position of tool, soft tool point, excessive strain from carrier, a piece of dirt in the dead-centre recess, a loose saddle or cross-slide, and variations in speed of the work. If the live centre is out of truth it does not follow that the turned surface is not cylindrical; the inaccuracy will be in the relationship of the periphery to the centre—that is, the outside of the bar will

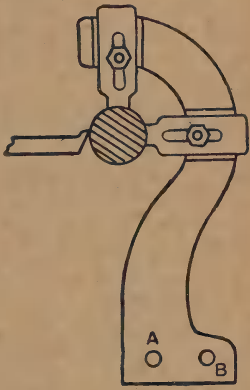
not be concentric with the centre recess. If several sizes are turned on the same bar with the live centre out of truth, the diameters will all be concentric ; and if the bar is to run in a bearing all will be well, provided that the position of the bar has not been moved in the carrier. If half the sizes are turned, the carrier loosened, the bar partly rotated on the centres, and the carrier screw tightened up, the turned portion will run out of truth ; it is for this reason that the writer does not recommend the practice of finishing from the tailstock end, reversing the bar and finishing the portion that originally was on the headstock centre. The better method—and the one already advised—is to turn right up to the carrier and then cut off ; of course, if the headstock spindle and the live centre are perfectly true, the work may be turned from each end.

If the carrier is so fastened that a strain comes on the tail, it may happen that the work is slightly bent when it is in position between the centres. As a consequence, the bar is not truly cylindrical when it is taken out of the lathe. This happens most frequently when a bent-tail carrier is used.

Hard and Soft Centres.—If no appliance is available for grinding the centres while revolving, the headstock centre had better be left soft. Very little wear comes on the live centre because the work revolves with it, whereas in the case of the tailstock or dead centre it does not revolve, but the work rotates upon it. If the live centre is turned up, hardened, and again placed in position, it will be seen that it runs out of truth, but it may be possible that one position can be found in which it runs true. The method of using a centre under these conditions cannot be recommended ; and unless it is possible to grind the live centre while revolving in the spindle after hardening, the headstock centre should be left soft.

The tailstock centre must be hardened on account of the great wear coming upon it, as previously explained ; and if it goes out of truth during the hardening operation, little harm will result. If a piece of hard material is being turned, and the tailstock centre is left soft, considerable wear will take place during the turning operation ; the result will be that the bar is neither round nor parallel. Both centres should be marked with either a centre-punch or fine chisel, and a corresponding mark made upon the lathe spindle, in the case of the live centre, and upon the tailstock barrel in the case of the dead centre. This will ensure that the centres are replaced in the same position as they previously occupied. This precaution is necessary in the case of the live centre if the lathe spindle is slightly out of truth.



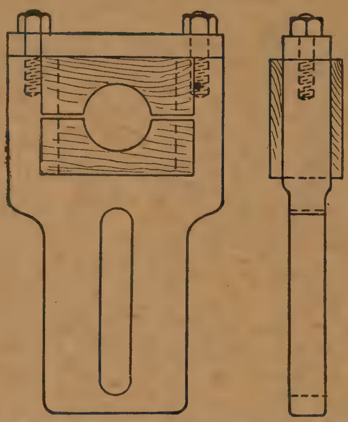


Figs. 46 and 47. — Fixed and Travelling Stays Respectively

Effect of Tool Being Too Low.—The incorrect position of the turning tool may cause work to be both untrue and unparallel. If the tool is placed too low it frequently happens that the bar is cut smaller as the tool recedes from the dead centre. In the case of a long bar this proceeding is dangerous, and may result in the work being thrown out of the centres.

Result of Wear of Tool.—It sometimes happens that in the case of a long bar it is not truly parallel. This may

happen although the centres are perfectly in line, and can be attributed to the point of the tool wearing during the turning process. To lessen the liability of this



Figs. 48 and 49.—Home-made Travelling Stay

happening, the tool should be as hard as possible and the finishing cut should be a light one.

Result of Slackness in Slide-rest.—If the saddle is loose on the bed, or if the cross-slide is slack, it will be impossible to produce good work. It is essential that no shake be present in any part of the machine, as during the turning of the bar the parts will constantly shift. Variations in speed will produce irregular surfaces, and if the lathe is stopped in order to change the belt on to another cone, it will probably be found that a different size is being turned; even if this is not so, a small groove will be cut in the bar when the lathe is again started.

Chattering.—The defect known as chattering may be produced in many ways, amongst which are: tool-post screws loose, thus allowing the tool a slight movement; blunt edge on tool; tailstock centre not screwed up sufficiently tight; headstock bearings loose, etc. If a tool that is ground for cutting cast-iron is used on mild steel, chattering is sure to occur, owing to the great amount of tool point presented to the work.

Use of Stay when Turning Long Bars.—If the bar is very long there is a probability of its being forced out of the centres. When very long and slender bars are turned a stay or support is necessary, otherwise the work may fall from the centres, and in any case accurate round bars cannot be turned. Fig. 46 shows a type of fixed stay that is often used. The casting A is clamped on the lathe bed B, the stay being so arranged that the top half C can be opened. The sliding pieces D, E, and F are held by means of nuts and bolts, and can be adjusted to suit various sizes of shafts.

A fixed stay is generally used when only a short portion of a long bar requires turning. If a long shaft is to be turned it is customary to use a travelling stay or a follower rest. Fig. 47 shows a travelling stay, which is fixed on the saddle by means of studs passing through the holes A and B. The bar is rigidly supported close to the tool with this form of stay, and large cuts may be taken. Care is necessary when fixing a stay in position, otherwise untrue turning and overheating will take place.

When a long, slender bar is placed between the centres it will be found that the centre part is bowed when left unsupported. A scribing block can be used for testing this in the following manner: The base of the block should stand on the bed, and the hooked end of the scriber adjusted so that it lightly touches the top of the bar near the dead centre. Next the block should be moved about half-way

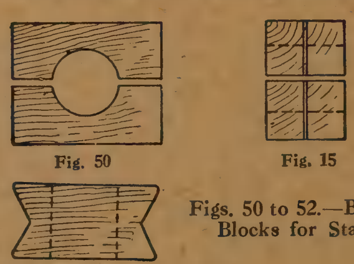


Fig. 50

Fig. 15

Fig. 52

Figs. 50 to 52.—Beech Blocks for Stay

between the dead centre and the live centre, and the bar tested there. It may be found that the bar is bowed $\frac{1}{4}$ in. or even more. When adjusting the stay the bar must be level, otherwise it may be thrown

out of the centres, and in any case the bar could not be turned parallel or round.

An effective stay can be made at little cost from some hard beech. It frequently happens that the worker does not possess a properly made stay, and that he wishes to turn odd sizes. A rough cast-iron bracket and a supply of beech blocks can be utilised. Should the hole in the blocks be too large for the work, strips of leather can be fitted round the bar. The use of beech blocks involves the employment of plenty of lubricating oil. A cheaply made stay is shown by Figs 48 and 49, and can be made of cast-iron, with a steel or wrought-iron strap across the top. If the strap has one plain hole, and one slotted hole, it may be swung clear to allow the blocks to be put in or taken out. The beech blocks (Figs. 50 to 52) must be made to

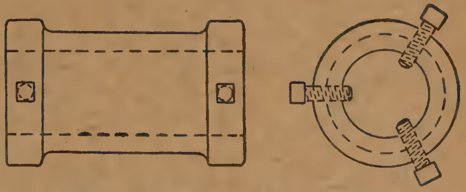
Figs. 53 and 54.—Angle Plate

fit the bevelled portions of the stay, and should be bored out in position. A small angle plate (Figs. 53 and 54) will be required for the purpose of fixing the stay on the lathe saddle. The angle plate can be made from cast-iron or mild steel; if of the former, a pattern will be necessary, and if of the latter, a piece of bar material can be heated to redness and bent at right angles.

Should it be desired to turn a long shaft at one end only, the bar having been roughly turned over before using a travelling stay, it is customary to use a sleeve as shown by Figs. 55 and 56. The sleeve is slipped over the end of the bar, and set to run true by means of the six set-screws that are provided. The sleeve is then mounted in the stay. After a length of the bar is turned, the sleeve can be removed and the stay fixed on the bare shaft where it has been machined.

POLISHING LONG SHAFTS

Filing in the Lathe.—After the finishing cut has been taken over the full length of the shaft, it is the usual practice



Figs. 55 and 56.—Sleeve for Stay

to use a smooth flat file for removing the tool traverse marks. Care is necessary in filing, inasmuch as it is easy to file a number of flats on the bar, and also to cut deep scores in the material. The work is, of course, revolving during the filing process, and the speed at which it should turn can be determined only by experience. Some authorities say that the work should be filed while running at the same speed as was used for the finishing cut. But the length and thickness of the shaft are important factors, and have to be considered when taking the finishing cut, and, generally speaking, filing can be done while the bar is revolving at a quicker speed than that used for the finishing cut.

The work must not revolve too quickly, or the teeth of the file will immediately be rubbed off when brought into use. The strokes should be very regular, and an even amount of pressure should be applied. The speed of the work should be such that

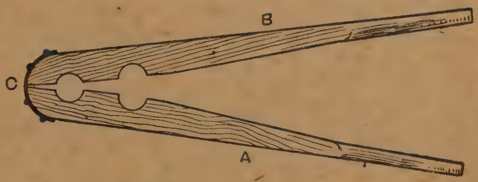


Fig. 57.—Polishing Cramp

it revolves several times during one stroke of the file. It is an easy matter to know by the "feel" of the file if it is cutting correctly. If a roughness, or a series of small jerks, is felt during filing, it is an evidence of "pinning." Sometimes a

number of filings get fast in the teeth of the file, and cause deep scratches to be made in the bar. Immediately this happens the file teeth must be cleaned out by means of a scriber point or, better still, with the aid of a file card (a kind of small wire brush). If the teeth are not cleaned out the filings will form small balls of hard metal, which will tear grooves in the bar. The grooves are cut in to a considerable depth, and cannot be removed by polishing with emery-cloth.

Using Emery-cloth in the Lathe.—Emery-cloth well supplied with oil is used for polishing shafts, and the polishing can be done at the same speed as that used for filing. The emery-cloth is sometimes held in the hand; but this is a somewhat dangerous proceeding, and a special holder should be made as shown by Fig. 57.

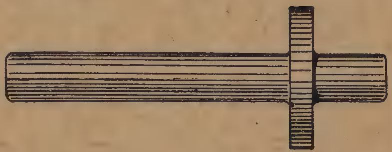


Fig. 58.—Bar to be Side-faced

Two pieces of stiff wood, A and B, are shaped as shown, and connected by means of a piece of leather C, which is fastened by means of screws. The emery-cloth is folded into a strip, and inserted in one of the hollowed-out portions. The emery-cloth must be so folded that the rough side touches the bar to be polished as well as the wooden cramp. If the smooth side of the emery-cloth is placed against the wood, the cloth will slip as soon as pressure is applied on the handles of the clamp, and an accident may result.

Oil must be plentifully applied on the shaft to be polished, and the emery constantly moved along. The amount of pressure to be applied can only be found by experience; if too much pressure is applied, the shaft will become very hot, be deeply scratched, and will probably run out of truth. The final polishing may be done by means of worn-out emery-cloth well soaked with oil. In this case the emery-cloth can be held in the hand as very little pressure is necessary, and, as the emery surface is smooth, there is little danger of seizing. Further, there may be some corners requiring polishing that the wood clamp has left unfinished; it is an easy matter to hold the worn emery-cloth so that it polishes the corners.

SURFACING FLAT WORK

When large flat work is being surfaced between the centres, it is usual to hold the work in a chuck and to fix an ordinary turning tool (Figs. 30 to 32) in the tool-rest at right angles to the surface that is being faced. In the case of a bar that has a collar turned on (Fig. 58), this would be impossible, as the work has to be machined while revolving between the lathe centres, for which purpose a left-hand side tool (Figs. 59 to 61) and a right-hand side tool (Figs. 62 to 64) are used. Some mechanics name these tools in exactly the reverse way, and call a tool that operates on a right-hand face a right-hand tool, and a tool that is used for a left-hand face a left-hand tool; but the names here used indicate to which side the tool is bent if viewed in the position it occupies when fixed in the lathe. Fig. 65 shows a right-hand tool being used for facing the side of a collar, and Fig. 66 a left-hand tool in use on a similar job. In setting a side tool it must be remembered that the smallest diameter regulates the height, and the tool must be set for this.

MEASURING AN EXTERNAL DIAMETER

There are several methods by which this can be done, the tools mostly employed being callipers, vernier callipers, and micrometers. For work of an ordinary character, and where close measurements are not required, callipers will suffice; but for fine work, and especially where great accuracy is desired, it is usual to employ either a vernier calliper or a micrometer. Close measurements can, of course, be obtained by means of callipers, but they have the disadvantage that totally different results may be obtained by different persons. Further, the callipers do not indicate in inches the size of the

bar that is being measured, and the result is entirely dependent upon the "feel" of the calliper when it is passed over the bar. Different results may be obtained by the use of micrometers in the hands of different persons, but as the dimension is clearly indicated on part of the instrument, the liability of incorrect measurement is not so great. A type of micrometer often used has a spring ratchet fitted so that when the anvil, or measuring point, is adjusted, the ratchet slips when the point touches the work. With this type, different persons would obtain the same reading.

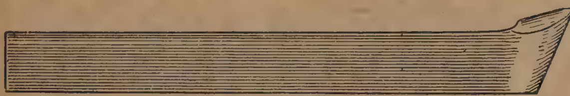


Fig. 59

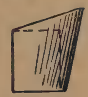


Fig. 60

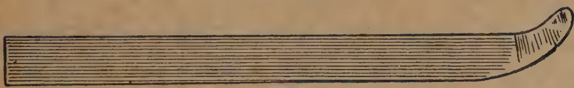


Fig. 61

Figs. 59 to 61.—Left-hand Side Tool

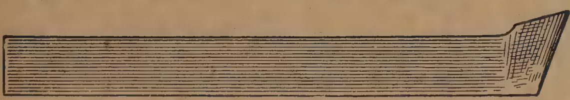


Fig. 62

Fig. 63

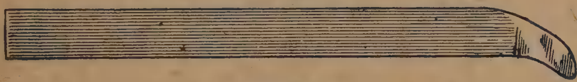


Fig. 64

Fig. 62 to 64.—Right-hand Side Tool

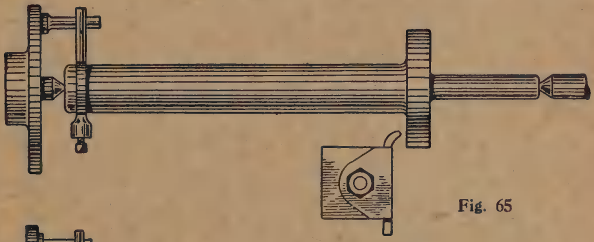


Fig. 65

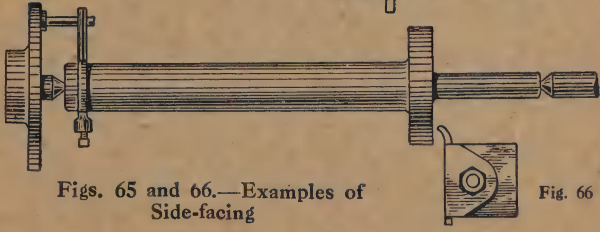


Fig. 66

Figs. 65 and 66.—Examples of Side-facing

When setting callipers to a standard plug gauge, or when it is desired to turn a bar the same diameter as a model piece, care must be taken that the "feel" of the callipers is exactly the same in both cases; if such is not so, the bars will be of different diameters. It must also be remembered that the callipers must be held in such a manner that the points are exactly at right angles to the axis of the work. The setting of a pair of callipers to a dimension on a steel rule requires care. One point of the callipers should be placed against the end of the rule, and the other point should "split" the graduation line at the desired place. Fig. 67 indicates a pair of outside callipers being set to $1\frac{3}{4}$ in.; as the graduations on steel rules are of considerable thickness, care must be taken in setting, otherwise, although working to one graduation, it would be easy to secure an incorrect result. The reader has already been warned (see p. 120) that callipers should not be used on revolving work.

When using a micrometer for measuring, it must not be placed against the bar when it is revolving, as the points are positively held by mechanical means, and cannot be pushed open as easily as can the points of a pair of callipers. Apart from this, any wear coming on the points, or anvil, of a micrometer will soon destroy the accuracy of the tool.

FEED AND CUTTING SPEED

When speaking of the amount of material that can be removed in a lathe by means of the cutting tool, it is usual to use two terms—feed and speed. The former denotes the distance that the tool traverses longitudinally during one

revolution of the bar; the latter indicates the rate at which the material passes in front of the tool. It is said that if a lathe were run for one minute, and the shaving

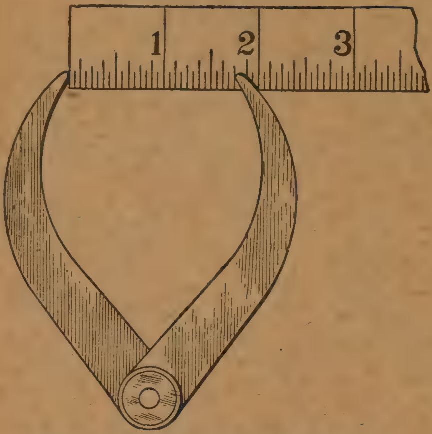


Fig. 67.—Setting Outside Callipers

produced straightened out, its length in feet would equal the cutting speed per minute. The writer cannot agree with this explanation, as the metal is greatly compressed and the fibre broken up as it is removed by the cutting tool.

In order to demonstrate the principle of cutting speed, the writer recommends that a piece of string of exactly the same thickness as the feed being used should be spirally wound round a cylindrical bar while it is revolving between the lathe centres; there must, of cou se, be no space between each turn. Now if an ink mark is made on one single strand, and the tool point placed exactly opposite, it is an easy matter to arrive at the cuttting speed by the following method: The lathe spindle is revolved at the speed desired, and when the ink mark comes exactly opposite the tool, the traversing mechanisn is put into action, the lathe is allowed to run for one minute and then stopped. Another ink mark is then made on the string exactly opposite the tool point, and the string cut through at the two marked places; the length of the string in feet equals the cutting speed per minute.

If it is necessary to know quickly the cutting speed, it is usual to employ a special instrument known as a "cut-meter" (Fig. 68), which is held upon the revolving bar, and the speed indicated at the window A. When an appliance of this nature is used, no calculation is necessary and no time need be noted, the speed in feet per minute being indicated. The cutmeter shown is held by means of the handle, and the wheel B, which is rubber-covered on its periphery, is driven by friction from the revolving bar. The instrument contains a magnet mounted upon the spindle, and is so calibrated that when the circumference of the wheel has travelled 1 ft. it is indicated on the dial. In engineering works it is necessary to use a cutmeter constantly in order to know that the lathes are working at the maximum cutting speed.

There are other methods of determining the cutting speed, such as arriving at it by calculation. The number of revolutions per minute (R.P.M.) of the work must be counted, and the result obtained as follows:

Fig. 68.—Cutmeter

$$\frac{\text{R.P.M.} \times \text{dia. of work in in.} \times 3{\cdot}1416}{12}$$

= cutting speed in feet per minute.

For instance, it is desired to know the cutting speed of a 4-in. bar revolving at 85 R.P.M. Proceeding as stated,

$$\frac{85 \times 4 \times 3{\cdot}1416}{12} = 89 \text{ ft. per minute}$$

cutting speed. The rule to remember is: R.P.M. multiplied by diameter in inches, multiplied by 3·1416, and divided by 12, equals the cutting speed in feet per minute.

In some instances it may become necessary to find at what speed the work should revolve in order to give a certain cutting speed. This is especially so when the cutting speed only is known. If the cutting speed is to be 50 ft. per minute, and the work is 6 in. in diameter, the number of revolutions that the bar should make in one minute is found out thus:

$$\frac{50 \times 12}{3{\cdot}1416 \times 6} = \frac{600}{18{\cdot}84} = \text{say, } 32 \text{ R.P.M.}$$

As the shaft is 6 in. in diameter, the distance once round is 6 × 3·1416, as the diameter × 3·1416 equals the circumference, which is in this case 18·84 in. The distance once round the bar is 18·84 in., and the necessary speed corresponds to the number of times that 18·84 in. is contained in 50 ft. The feet have to be reduced to inches, this giving (50 × 12) 600. Dividing 600 by 18·84, 31·9 is obtained, this being the speed at which the work should revolve.

The use of high-speed steel has revolutionised metal turning, feeds and speeds now being in daily use that were a few years ago thought impossible. In ordinary circumstances, and especially when turning work of small diameter, it is quite impossible to work a high-speed tool up to the limit of its efficiency. The writer has frequently had in use tools with the nose red-hot, and little damage appeared to result. Messrs. Armstrong Whitworth removed in a day of ten hours no less than 2,480 lb., or considerably more than a ton, of material, by the use of one tool made of "A.W." high-speed steel. The cutting speed employed was 160 ft. per minute, the maximum depth of cut $\frac{3}{4}$ in., and the feed thirty-two cuts per inch.

The following particulars are from tests made when using "Novo" high-speed steel. When turning unannealed cast steel, a cutting speed of 110 ft. per minute was used with the cut $\frac{1}{8}$ in. deep and a feed of $\frac{1}{8}$ in. per revolution; a steel shaft was turned at the rate of 232 ft. per minute, with a $\frac{1}{4}$-in. cut and $\frac{1}{8}$-in. feed; on cast-iron a cutting speed of 247 ft. per minute, a cut $\frac{1}{4}$ in. deep and a feed of $\frac{1}{8}$ in. was used. By comparing these results with the cutting speeds given in the table for carbon steel, the revolution caused by the introduction of high-speed steel in engineering works will easily be understood.

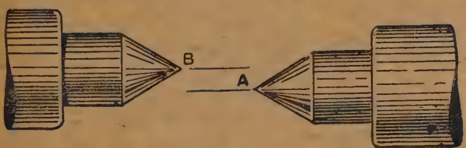


Fig. 69

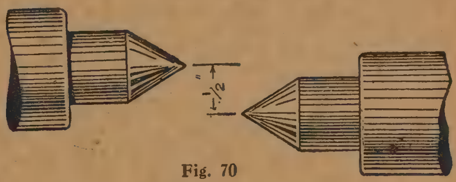


Fig. 70

Figs. 69 and 70.—Lathe Centres Set Out of Line for Taper Turning

Very little forging is done when making tools from high-speed steel, as they are generally ground to shape on an emery-wheel. Though this class of steel is easy to forge if the maker's instructions are closely followed, it is also an easy matter to spoil the steel during the heat treatment. It was by accident that Mr. Taylor, of the Bethlehem Steel Company, of America, discovered in 1898 that if certain brands of steel were heated to melting point, and then cooled by means of an air blast, it was possible to use phenomenal cutting speeds. In the year 1857 Robert Mushet introduced a brand of steel known as "Mushet's self-hardening steel," but it did not give such results as are obtainable from the use of high-speed steel. The writer has found that for finishing cuts tools made of carbon cast steel give better results than those made of high-speed steel. Finishing cuts are generally done at a slow speed.

TAPER TURNING

There are several methods by which tapered work can be produced, these including the setting over of the tailstock or the use of the compound slide-rest. If much tapered work is required, it is usual to produce it on a special lathe where the headstock and tailstock can be moved diagonally in relation to the saddle, this class of lathe being greatly used in America.

A simple method is to fix the dead centre A and the live centre B out of line, as shown in Fig. 69, which is a plan of the two centres placed close together. The amount by which the tailstock centre is set out of line will depend upon the taper required. For instance, if it is desired to turn a bar 12 in. long, 3 in. in diameter at the large end and 2 in. in diameter at the small end, it will be necessary to set over the tailstock $\frac{1}{2}$ in., since the bar has a total taper of 1 in. to the foot; the taper on one side of the work is only $\frac{1}{2}$ in., and it thus follows that the tailstock has to be put out of line by $\frac{1}{2}$ in., as clearly shown in plan by Fig. 70.

When the centres are placed out of line in this manner, the tool cuts off from one side of the bar an amount of material equal to the distance that the centres are out of line.

A good method to adopt when taper pieces are required is to place a finished taper piece between the lathe centres and then to test the taper with the point of the tool placed exactly level with the vertical centre of the work. The test piece having been removed, the saddle must be moved along and the work set over until the tool point just touches the work at each end.

Fig. 73.—Tool Post Swivelled for Taper Turning

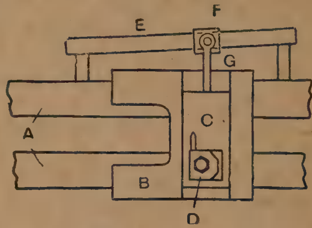


Fig. 74.—Taper-turning Attachment

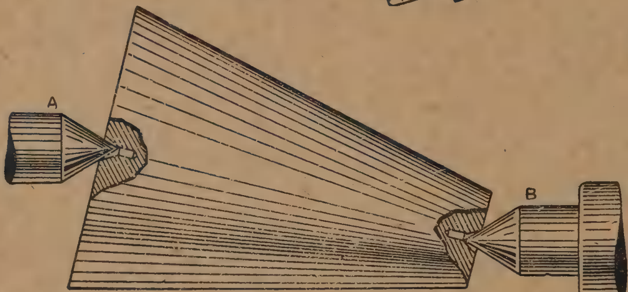


Fig. 72.—Excessive Setting Over of Lathe Centres

Fig. 71.—Position of Tool for Taper Turning

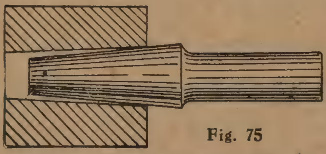


Fig. 75

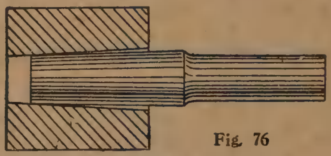


Fig. 76

Figs. 75 and 76.—Tapered Bars Forming Bad Fits in Holes

Accurately Copying a Taper.—When an accurate copy of a taper is required, it is advisable to test the taper with a piece of cigarette paper between the tool point and the work. The manner of testing is as follows: The tool is fed up against the taper bar at the tailstock end and the piece of thin paper placed between the tool point and the bar. Without drawing the tool away from the work, the saddle is moved longitudinally until the tool is opposite the large end. If the tissue paper fits here in the same manner as it did at the small or tailstock end, the tailstock is set over correctly. During this testing no carrier has been placed on the bar, and it must be remembered that the tool point should be placed exactly on a line with the centre of the work, as shown by Fig. 71.

The setting over of the centre to a great amount is not desirable, it having the effect shown by Fig. 72, A being the live centre and B the dead centre. Neither of the centres fits the recess, as shown by the broken-away parts of the bar. If a great amount of taper is desired it must be turned by means of the compound slide-rest. If the work is placed as shown by Fig. 72, the large end will constantly be moving to and fro as the work revolves.

Turning Short Taper.—The method of turning a short taper by means of the compound slide-rest is shown by Fig. 73. The tool post is swivelled round on its base sufficiently to produce the desired taper; in other words, the slope on the front of the tool post, in relation to the axis of the work, should exactly equal the desired taper.

Taper-turning Attachment.—The lathes generally used in England for taper turning are fitted with a bar at the back of the bed that can, within certain limits, be moved diagonally in a horizontal direction. Fitted on the bar is a sliding piece which is fastened loosely to the cross-slide. The cross-slide screw is taken out, thus permitting the cross-slide to be moved to and fro at right angles to the lathe bed; but in this instance, as the sliding piece fits over the bar at the back of the bed, the cross-slide cannot be moved. When any taper turning is required, the bar is set diagonally according to the amount of taper desired, and the tool fixed in the slide-rest, which is fitted with a supplementary cross-slide for the adjustment of the tool. Now, when the saddle traverse is put in motion, the saddle moves towards the headstock, and the cross-slide being attached by a sliding piece to the bar, recedes from or advances towards the centre of the work, according to the position of the bar, thus producing the desired taper. Fig. 74 shows diagrammatically the principle of the mechanism, A being the lathe bed, B the saddle, C the cross-slide, D the tool-rest, E the adjustable bar, F the sliding piece, and G the rod attached to the cross-slide and sliding piece.

If the tapered work is required to fit into a taper hole, the bar should be tested in the hole to see that it fits correctly. If the bar has too much taper, the result will be as shown by Fig. 75, the bar tightly fitting at the entrance to the hole; it may also be rocked to and fro by hand. Should the bar have too little taper, the result will be as shown in Fig. 76. In this case the small end of the bar fits the hole and leaves a space round the large end. After the necessary adjustments have been done, several trials been made, and the bar appears upon testing to be of the correct shape, it should be chalked in three or four places along the full length and then inserted in the hole. The chalk will be rubbed off where the bar fits the hole, and it will be an easy matter to note if the taper is correct; if it is not, the necessary adjustments must be made.

HAND TURNING

Metal turning by means of tools supported on a T-rest and held in the hands of the workman was the rule until the beginning of the nineteenth century, when the desirability of adopting a mechanical system of ensuring accuracy began to be recognised. Accuracy in hand turning depends entirely upon the skill of the worker, and it is undeniable that results from the use of a slide-rest put hand turning absolutely out of court, both in point of speed and accuracy. From the

moment slide-rests were generally adopted the art of hand turning began to decline, with the result that to-day, as far as the amateur is concerned, it has become a wellnigh lost art. Many will regret this, and they argue that, among amateurs in tool is pardonable, but that to waste half an hour in preparing a special tool and rigging it up in the tool post, when the job could be done almost as efficiently in ten minutes with a hand tool, is not particularly commendable.


Fig. 77.—Graver


Fig. 78.—Triangular Tool


Fig. 79.—Hook or Heel Tool


Fig. 80.—Round-nose Tool


Fig. 91.—Planisher or Burnisher


Fig. 81.—Flat-ended Tool


Fig. 85.—Clearance in Iron-turning Tool


Fig. 82.—Square-ended Tool

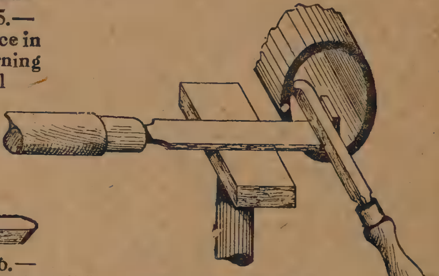


Fig. 88.—Using Tool in Arm-rest


Fig. 83.—Bead-working Tool


Fig. 86.—Brass-turning Tool


Fig. 84.—Parting Tool

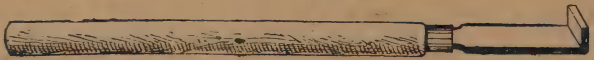


Fig. 87.—Arm-rest


Fig. 89


Fig. 90

Figs. 89 and 90.—Two Bent Tools

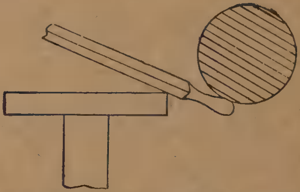


Fig. 92.—Using the Planisher or Burnisher

general, there are numberless occasions—occasions when accuracy of finish is not the first requirement—when skill in hand turning could be applied most usefully. They point out that the ambition to do everything with the slide-rest and fixed

Hand-turning Tools.—These tools differ in many respects from fixed tools in that their cutting edges are usually given a different angle; they do not need so great a body of metal to back up their cutting edges in order to give them strength

and rigidity, and the shapes of the cutting edges are not the same. A fixed tool may be made and ground for a specific purpose, and then, when set in the tool post, not give satisfaction owing to its being improperly placed or its edge incorrect in angularity. But with a hand tool a fault may be often rectified in an instant by a mere elevation or depression of the wrist. parting tool (Fig. 84) is, as its name implies, more often used as a single purpose tool—namely, for parting off work of a cylindrical character—but it may also be used with equal success in square recesses, such as piston-ring grooves or for squaring up the ends of round stock held between the centres. Tools used for brass need considerably less clearance

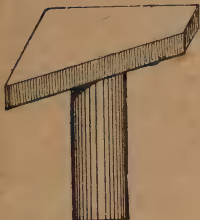


Fig. 93

Fig. 95

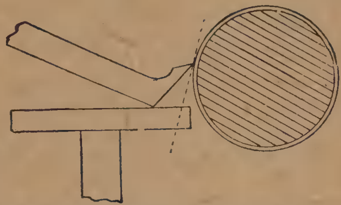


Fig. 99.—Incorrect Position of Hand-turning Tool

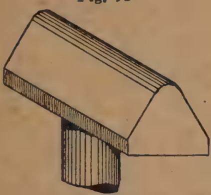


Fig. 96

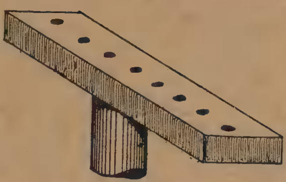


Fig. 97

Figs. 93 to 97.—Various Forms of Tool-rests

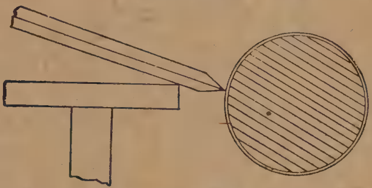


Fig. 100.—Position of Triangular Tool

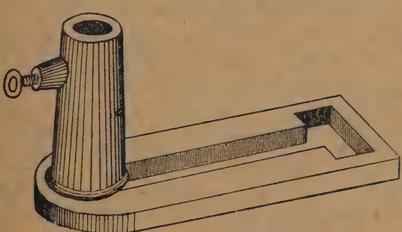


Fig. 98.—Adjustable Rest-holder

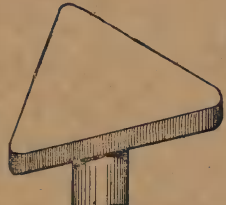


Fig. 94

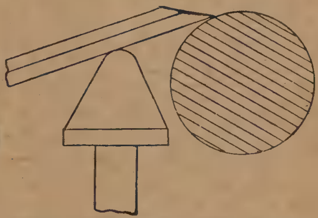


Fig. 101.—Position of Graver in Hand-turning

The three principal tools used in hand turning are the graver (Fig. 77), the triangular tool (Fig. 78), and the hook tool, sometimes termed a heel tool (Fig. 79), all being suitable for iron or steel. For brass or gunmetal the round nose (Fig. 80), the flat (Fig. 81), and the square end (Fig. 82) are the usual shapes in practice. Fig. 83 illustrates another form of tool used for iron or steel; it is eminently suitable for getting into hollows of small radius or working round beads, etc. The angle than for iron or steel. The two most favoured shapes in this respect are shown by Figs. 85 and 86, where the first illustrates the amount of clearance needed for iron, and the second the shape of tool used for brass, there being no clearance in the second case.

Worn-out triangular or square files up to $\frac{1}{2}$ in. thick are often used for making these tools. The file should first be thoroughly annealed throughout its entire length, otherwise a jar or a blow

which it may sustain in use will break it. It is also advisable to grind the teeth edges down on an emery-wheel or grindstone in order to prevent their biting into the face of the rest when in use, and to prevent the tool breaking when hardening; this is a common occurrence when tools are made from files and have some teeth grooves left in. A handle not less than 12 in. long should be used.

Arm-rest.—With both brass and iron turning it sometimes happens that it is required to bore out or end-recess a piece of work, which, by reason of its formation or shape, will not accommodate itself to the reach of an ordinary tool-rest. When such is the case, it is usual to have recourse to the tool known as the arm-rest. As shown by Fig. 87, this is a bent steel tool ½ in. by ¼ in. in section, one end of which is upturned ½ in., the other end driven into a long, stiff, parallel handle about 15 in. or 18 in. long. In use, this is held rigid under the left armpit, its steel end resting across the tool-rest and projecting therefrom such a distance as will permit the turning tool being used axially with the work (see Fig. 88), the tool taking its pressure and being supported from the end of the arm-rest. Figs. 89 and 90 show two bent forms of tools intended for boring or recessing.

Planisher or Burnisher.—A set of hand-turning tools would be considered incomplete without a planisher or burnisher. This tool is shaped something like Fig. 91, its end rounded as shown, filed perfectly smooth, hardened, and then given a perfect deep polish on a piece of buff leather, using crocus powder as an abrasive medium. The tool is used for imparting a brilliant surface finish to the work, and in use is pressed against the under-side of the work whilst revolving at top speed, the rest serving the purpose of a fulcrum (see Fig. 92).

Tool-rests.—The various forms of tool-rest are shown by Figs. 93 to 97. The first four are commonly used in connection with the turning tools for iron and steel, the latter being the form in general use amongst brass finishers. A typical adjustable rest-holder is shown by Fig. 98; the adjustability is secured by means of a T-headed bolt passing down through the lathe bed, and terminating with a wing-nut and plate, or cast-iron washer. The vertical adjustment to meet the varying diameters of the work is secured by means of the tightening screw set into the side of the holder.

How to Use the Tools.—For reducing work from the rough stock it is the usual practice to begin with the heel tool (Fig. 79), this being the most powerful of all the hand tools. The correct position to hold this, relative to the work, is with the front face almost tangential, as shown by the dotted line in Fig. 99. The tool itself, in this figure, is shown in an incorrect and dangerous position; considerable resistance will be necessary at the handle end to counteract the leverage strain due to cutting, and the least jar imparted to the tool by the work will, if the operator be caught at an unwary moment, cause it to dig in, spoiling and perhaps breaking the work.

The triangular tool has three cutting edges, each of 60° angle. If means are to hand for slightly curving these lengthwise, converting the flats into convex faces, the efficiency of the tool will be considerably enhanced. It is held in position a little under hand; that is, with the handle end highest, and the point of the tool slightly above the centre line of the work, as in Fig. 100. Thus the cutting strain is counteracted by depressing the handle, the rest, as before, forming the fulcrum.

The graver is more or less a finishing tool, its purpose being to smooth down the rings of ridges left by the previous tools. If nicely ground, its edges finished on an oilstone, and held as indicated in Fig. 101, it will peel off a beautifully thin shaving almost the width of the cutting edge, without distressing the tool in the least, and demanding no appreciable effort to keep it to its work. It will be noted that the form of rest used in conjunction with this tool is that shown in Fig. 96, its advantage over the flat types for this particular purpose being apparent. Moreover, it is possible for an expert to take a sliding cut with it.

Player-piano Adjustment and Repair

EXCEPTING actual damage caused by bad usage or accident, most of the faults that occur in the playing mechanism of player-pianos are due to want of adjustment or the accumulation of dust, etc., under valves and in the air passages. Logical reasoning is the only method of diagnosing any particular fault, and this can only be carried out if the sequence of operations of the action is known.

Principle of Working. — With very few exceptions all players are based on the same principles, and though the parts may be differently disposed, and in some cases elaborated, the fundamental operations remain the same. For instance, the double-pneumatic action is an elaboration of the single-pneumatic, and the same principle obtains.

What are termed the pneumatics are the series of units—one for each note—that constitute the striking mechanism. One of these is shown in section in Fig. 1, but it must be understood that, though each one acts independently of the others, they are not built singly. When studying this diagram it should be borne in mind that the bellows operated by the feet are not bellows in the ordinary sense of the word, but are exhausters, and that whilst being worked are tending to produce a vacuum in the chambers and ducts which are connected to them.

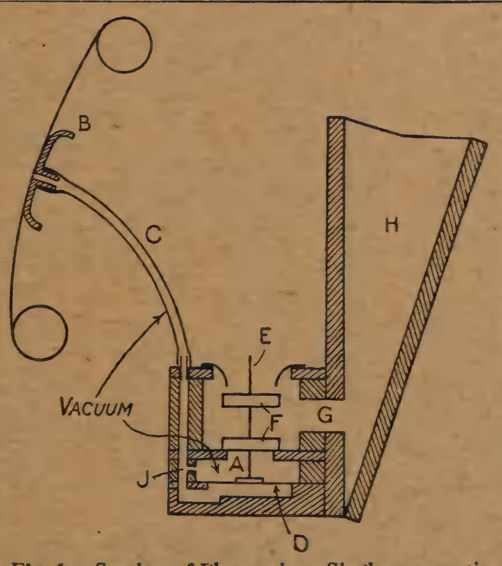


Fig. 1.—Section of Player-piano Single-pneumatic with Hole in Tracker-bar Closed

In order to understand the method of working from the diagram (Fig. 1), it must be supposed that the ends are closed, with the exception of an outlet to a passage leading to the exhausters. In actual practice the chamber A is common to all the units, but all the other passages and spaces relate only to the one particular unit. It will now be possible to follow the action of the pneumatic. In Fig. 1 (which figure shows really a cross section of the playing

mechanism) B represents the tracker-bar, over which the perforated paper passes, C is the tube and duct connecting the tracker-bar with the unit, D is a soft leather diaphragm, or puff as it is technically called, and E is the wire stem of the double valve F, and from between the faces of which a duct G leads to the small bellows or motor H. What is termed a leak-hole is situated at J or in some position connecting the duct C to the chamber A. The function of this hole will be explained later.

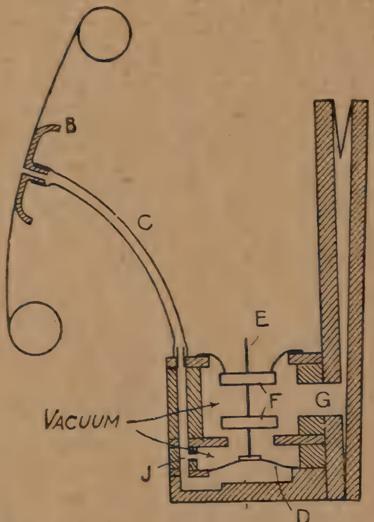


Fig. 2.—Section of Player-piano Single-pneumatic with Hole Open

Suppose now that the foot exhausters are worked and the hole in the tracker-bar remains closed. All that happens is that a state of vacuum is produced in the chamber A and the tube and duct C, the air being drawn out of these latter via the hole J. This state of affairs is indicated in Fig. 1.

Now assume that a perforation in the paper roll uncovers the hole in the tracker-bar. Air immediately rushes down the tube and duct C, and as it cannot get farther than the soft leather diaphragm D (with the exception of the small leak-hole) it presses this up, and the valve stem, resting on or just above the diaphragm, is also lifted, and with it of course the valve head, which now presses against the upper seating, thus putting the vacuum chamber A into communication via the duct G with the small bellows or motor H, causing this to shut up and thus actuate the note. This condition (see Fig. 2) exists exactly so long as the hole in the tracker-bar remains open; but immediately the hole is closed there is no longer any air pressure under the diaphragm, and this consequently falls and the small bellows or motor H is once more placed in communication with the outer air. The power delivered by the small bellows or motor, actually, is due to the pressure of the air on the outside, which causes a sudden collapse of the bellows immediately the air is withdrawn from the inside. The function of the leak-hole will now be obvious, for it allows the air to be drawn out of the tube and duct C, and a vacuum maintained under the diaphragm so long as the hole in the tracker-bar remains closed, thus preserving its normal balance.

The double-pneumatic may now be considered. Fig. 3 is a diagram of this with the hole in the tracker-bar closed. Reverting to the single-pneumatic for a moment, it is evident that all the air required for raising the diaphragm, plus that which passes through the leak-hole, must pass through the hole in the tracker-bar, and this necessitates a comparatively large hole in the bar. In the double-pneumatic system there is what might be termed a small relay valve, the purpose of which is to admit air to the under part of the main diaphragm direct from the outer air, and so giving this quicker and more positive action, for the air has not to pass along restricted passages as in the case of the single-pneumatic action. Fig. 3 shows clearly how this is brought about. It will be noticed that there is an additional, though smaller, vacuum chamber A1 and a small reversed valve. The remaining details are the same as for the single-pneumatic. When air is allowed to pass down the tube and duct C, the diaphragm K lifts the small double valve, and places the chamber under-

neath the large diaphragm in communication with the outer air.

Note Remaining Down.—It will now be clear what the condition of affairs should be for the correct actuation of the notes for either the single or double action, and that such matters as the incorrect seating of the valves, leak-holes of wrong size or stopped up, diaphragm too loose, etc., will reveal themselves in various ways. What is applicable to the single-pneumatic is also fairly applicable to the double, though in the latter it is necessary to discriminate whether the trouble is due to faults in the primary or the secondary system. As stated earlier, logical reasoning is the best guide to the elucidation of a fault. Take, for instance, a common fault — that of a note remaining down the whole time the instrument is being played, or only rising after a considerable interval. Consider now what could cause this. In the first place it may be something of a purely mechanical nature — that is, some of the moving parts binding or strained — and all should be carefully tested for freedom. Other causes might be the paper of the roll not bedding properly on the tracker-bar, a leak in the tube leading from the tracker-bar to the valve box, the valve not leaving its top seat owing to tightness of the valve stem, or some obstruction on the lower seat. It will thus be seen that a fault may be due to one or more of a number of possible causes, and that it is no use jumping to hasty conclusions.

Note not Playing.—In like manner a note not playing may be due to such matters as a diaphragm too slack, valve not seating on its top seat correctly, etc. If a diaphragm is too slack it will not lift the valve, but simply bulge out round the bottom of the stem. Such a trouble is very difficult to cure, for a number of diaphragms are all of the same piece of leather, and if one is to be renewed it means renewing the lot, a matter necessitating a considerable amount of dismantling. Stoppage, or partial stoppage, of a leak-hole may account for a host of troubles, among which are the slow recovery of a note, note not sounding, and faulty repetition.

Clearing Tubes and Leak-hole.—Special pumps are obtainable for the purpose of extracting dust from the tubes, or a pump can be improvised by reversing the leather on a cycle pump and fitting the nozzle into a pad of rubber cut to fit over the tracker-bar. Do not attempt to clear the tubes, etc., by probing with wire or by blowing into them. The dust should either be sucked out or the instrument dismantled.

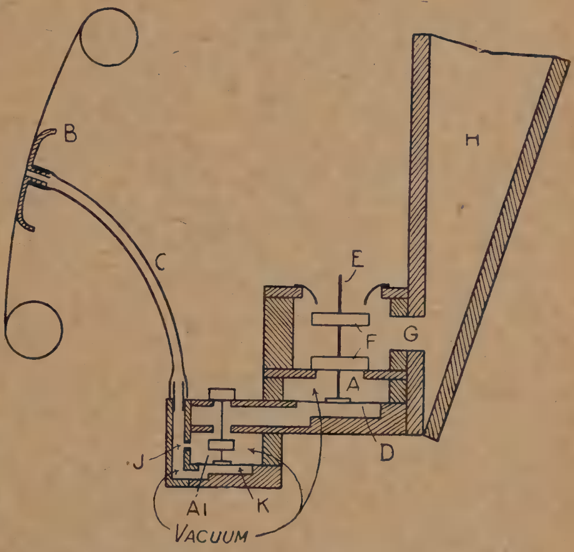


Fig. 3.—Section of Player-piano Double-pneumatic with Hole Closed

Unfortunately leak-holes are very troublesome to get at, and specific instructions cannot be given as to the mode of procedure, for it is seldom that they are located in the same place, or under the same conditions, in different makes of instruments. As it is essential, however, that they should be situated somewhere between the tracker duct and the main vacuum chamber of single pneu-

matics, or between the tracker-duct and the primary vacuum chamber of double-pneumatics, their location may be fairly easily arrived at, although some dismantling will be necessary. Often they consist of a paper or fibre disc through which a needle has been pushed. In clearing a leak-hole, should the existing hole be enlarged by error, a new disc can be stuck on. There is no standard size of hole, for they vary according to the player. The only guide the repairer has is the size of the other holes or experiment.

Valves.—In some instruments the valve stems are screwed into a small piece of leather attached to the diaphragm, and the heads are made in two pieces, one for the upper seat and one for the lower seat, as shown in Fig. 4. The heads are adjustable by screwing them up or down, and the height of the stem is adjustable by screwing it out of or into the leather pad on the diaphragm. Another form of valve has a solid head, which therefore is not adjustable between the two faces, though the position of the head can be varied on the stem (see Fig. 5). Sometimes also the stem is not in actual contact with the diaphragm, but hangs a little above. In each case it is necessary that the valve should seat properly on the lower seat when the diaphragm is normal, and on the upper seat when the diaphragm is distended.

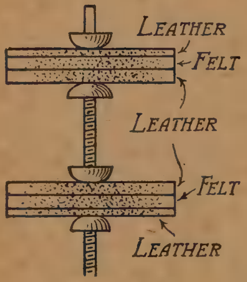


Fig. 4.—Player-piano Valve with Double Head

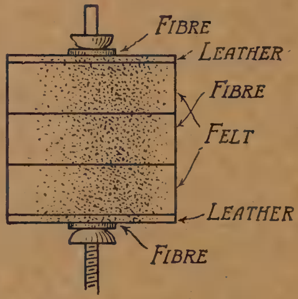


Fig. 5.—Player-piano Valve with Single Head

The usual lift of a primary valve is a trifle over $\frac{1}{32}$ in. and of a secondary valve about $\frac{3}{32}$ in., therefore careful and fine adjustment is necessary. The governing factors are the amount of swell on the diaphragm, the distance of the valve seats from the diaphragm, and the distance between the upper and lower valve seats. A diaphragm may sometimes be improved, especially if it is too slack, by the application of a little collan oil.

Two Notes Sounding when One is Played.—If more than one note sounds when only one is played, it reveals the fact that there must be some leakage between the units playing those notes, perhaps owing to a diaphragm having become unglued or the wood having split. The paper of a roll not bedding correctly on the tracker-bar would also cause this, but the fault then would only be present when certain rolls were being played.

Roll-driving Motor.—Trouble with the roll-driving motor is often of a mechanical nature, and careful examination and testing will show where the fault lies. Allow the driving chains to be fairly slack, and make sure that the pinion wheels mesh easily and do not bind. Means of adjustment are usually provided. Also examine the slides of the valves, and make sure that they work freely yet air-tight. The crankshaft should be tested for freedom in its bearings. When considering the roll-motor it must be borne in mind that the air passes in a reverse direction to that which it would in an ordinary compressed-air motor; that is, it is drawn directly into the motor and then through a governor and then into the exhausters. The governing action is controlled by a spring, and should this spring be too weak sufficient air will not pass through, and therefore the motor will be sluggish. The remedy is to increase the tension of the governor spring. If the motor works too fast, or is susceptible to varying pressure on the pedals, the converse is the case. In this connection, and in fact in the faulty working of any part of the

instrument, leakages should, of course, be sought for.

Controls.—Such matters as incorrect response to controls are usually due to want of adjustment of control levers and rods. The path of a control should be traced out, when usually the fault will be detected. Notes playing during re-rolling are often due to a bent or strained control lever, which does not correctly operate the slide shutting off the notes.

Leakage.—Should an instrument require a very quick action of the feet to maintain a suitable vacuum, search should be made for leakage. The first thing is to examine the bellows. There is a possibility of the covering of the exhausters having become worn through in places, the corners of the gussets or the hinge being the most likely. If on examination of these places they should be found all right; the valves of the exhausters must be tested, and if curled, new valves should be fitted ; but if they are slack they may be taken up. To test for the valves on the inside of the bellows, the lever should be pushed over to the re-roll position, and the tube connecting the roller motor disconnected and stopped up. The pedals should then be moved, at the same time watching the main reservoir. This should remain fairly steady on the return stroke of the pedal, but if it should open out on the return stroke the inside valve is at fault. To remedy this the covering will have to be taken off the exhauster, which is at fault, and a new valve fitted. The valves must not be stretched when fitting or left too loose, as in the former case they will cause a buzzing noise, and in the latter case will lose air, and a loud snap will be heard on the return of the pedal.

Lubrication.—Working metal parts should be lubricated with non-gumming oil, but on no account should oil be used on wood, for it causes it to swell. On wood parts that are out of sight, dry graphite should be used and on other parts french chalk. French chalk is also useful for the prevention of squeaks in the leather bellows, etc.

Making Walking-sticks

ASH, cherry, blackthorn, firs, malacca, bamboo, etc., are known in the trade as natural sticks as they are left with their natural bark or enamel on. Ash should be cut when it reaches its correct size, $\frac{5}{8}$ in. to $1\frac{1}{4}$ in., and the method of cutting is to obtain a natural handle, called a pull down or crutch hook (Fig. 1, *next page*). At some stick plantations the roots and boughs are clamped in position when quite young, so that they grow into the position required, but all hooks (Fig. 2) are bent by heat. Before bending, all sticks must be thoroughly seasoned, the time varying from four months to two years.

Bending C-hooks.—Assuming that the reader has cut a few sticks, seasoned them, and now desires to bend to **C**-hooks, first obtain a piece of hardwood, and turn it down as shown in Fig. 3. A is separate from B. Cut and fit together with a flange, so that A can be removed after the stick is bent. Into the side of B drive a piece of bent iron $\frac{3}{8}$ in. in diameter, and this will complete the bending block. Next obtain a biscuit-tin and cut from the lid three strips of tin $1\frac{1}{2}$ in. wide and rivet to one side of the box (Fig. 4). The recess thus made should be filled with silver sand. Inside the box place a gas ring, thus completing a cheap and portable kiln.

Take the sticks to be bent, place them in the sand, leave them there until they are hot right through (for fifteen to twenty minutes). Take one out, place the end between the hook and the block, and slowly bend round, at the same time pulling

towards you. When completely bent, tie from the nose to the neck with string (see Fig. 5), then remove block A, and take off the bent stick. Leave to harden in a warm place for twenty-four hours, when the string may be removed. Cut the stick to length, 36½ in. being the average length, file and glasspaper.

Bamboo before bending is filled at the part to be bent with sand, where this is possible. For bending, put the bamboo root in the vice, apply a gas-jet and pull round very carefully by hand.

Finishing.—Look over the stick for bark that has peeled off. This should be glued on again. If glue gets on to the bark wipe off with a rag dipped in hot water.

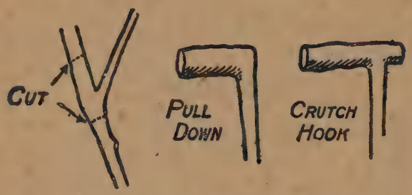


Fig. 1.—Natural Handles of Walking-sticks

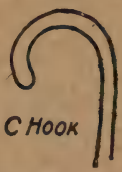


Fig. 2.—Bent Handle

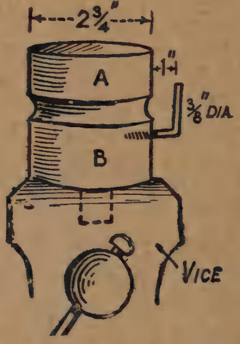


Fig. 3.—Bending-block for Stick Handles

Fig. 5.—Stick in course of Bending

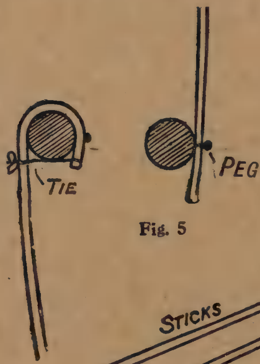


Fig. 5

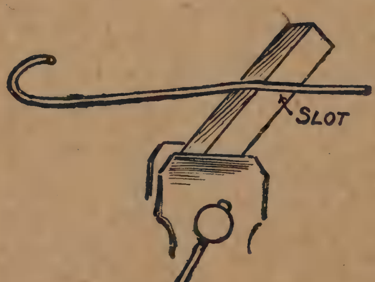


Fig. 6.—Using the Straightening-horse

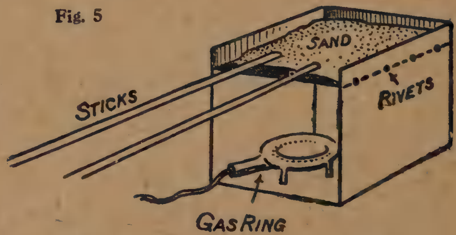


Fig. 4.—Kiln for Heating Sticks

Straightening Sticks. — The next operation is to straighten the stick. Obtain a piece of wood, 12 in. by 6 in. by 2 in., and slot it as in Fig. 6. Fix one end in a vice and a straightening-horse is formed. Warm the parts of the stick to be straightened in the kiln, place in the slot of the horse and apply pressure until straightened. Ash, cherry and malacca bend well, but birch, beech, partridge and ebony soon break.

Bark broken during bending should be glued and bound down with tape and left for twenty-four hours.

Next wash the stick with pumice and water to remove dirt and leave a smooth surface. Give the nose three coats of white shellac varnish, and the stick is finished. If desired the stick can be given one coat of varnish applied with a flat sponge. This method is carried out with all natural sticks except bamboo.

Dressing Skins for Rugs

In dressing skins either of two distinct methods may be employed. The first is known as "tawing" or white leather making, this being the system chiefly in vogue, in the performance of which the worker may have the choice of several chemical formulæ. The second method is one more generally associated with leather making, namely, tanning. Under no chemical treatment at present known can a skin or hide be reduced to complete suppleness without the further purely mechanical process of "currying," and it is on the thoroughness with which this is performed, either by hand or machinery, that the extent of softness is gained.

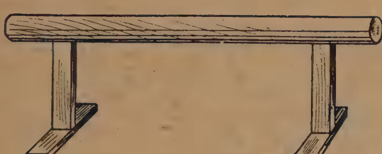


Fig. 1.—Horse or Beam

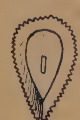


Fig. 4.—Shave-hook with Serrated Edge

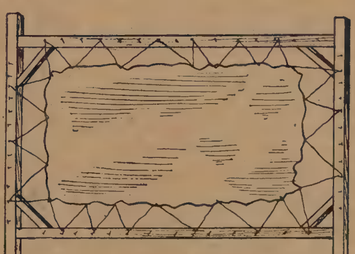


Fig. 5.—Skin Frame

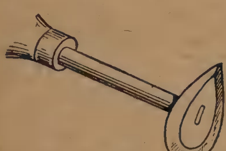


Fig. 3.—Shave-hook

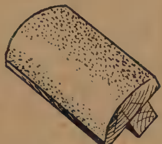


Fig. 6.—Glass-paper Block

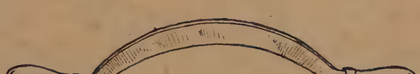


Fig. 2.—Two-handled Shaving Knife

Implements.—There are certain special tools employed by furriers, the deft use of which can only be attained by practice, but which form a necessary part of the equipment when work has to be performed rapidly.

The horse or beam (Fig. 1) is generally constructed of a length of scaffold-pole, supported about 2 ft. 6 in. from the ground by two upright pieces of wood, which may either be fitted with feet or, better still, planted into the earth in the work-shed. This is intended to receive hides of fair size during the processes of fleshing and currying.

The two-handled shaver (Fig. 2) is

generally used for reducing skins worked on the "horse." This tool may be either single- or double-edged, and is more or less flexible.

The shave-hook (Fig. 3) is intended for dressing skins of small or moderate size, which are laid out on a flat surface or stretched on the skin frame (Fig. 5). If the edges are serrated by means of a file (as in Fig. 4), the tool will be found most useful in breaking up the surface of stubborn skins.

The skin frame (Fig. 5) is largely used for stretching, and thereby flattening, pelts of small or moderate size.

For finishing, the glasspaper block (Fig. 6) will be found very useful. In the form shown, the paper is attached to the rounded surface by means of glue; but as the glass shale wears away rapidly, a more convenient tool in which the paper can be renewed easily may be made out of an ordinary hand blotter.

Fleshing.—The first thing to be done with a freshly stripped skin is to remove every particle of flesh, fat, and loose tissue. This operation, which is known as "fleshing," is performed by throwing the skin across the beam or laying it out on a table and scraping it all over with either the shaver or the shave-hook. When this has been thoroughly carried out the skin is ready for tawing or preserving.

Tawing.—There are several formulæ in common use; the best for skins of moderate size consists of flour 6½ oz., alum 3¼ oz., salt 1½ oz., olive oil 1½ dr., with two or three eggs and sufficient warm water to mix. Another, almost as good, is made of rock salt 2 lb., alum 1 lb., sal-ammoniac 1 oz., and 2 gal. of warm water. Both of these preparations are intended for application only, and not as liquids in which the skins should be immersed.

The skin should be laid out in a cool place or stretched on the frame, and kept constantly moistened for two or three days with the preservative, which should always be applied in a tepid condition and well rubbed in.

Larger skins can be tawed by complete immersion in a solution or curing bath made of 1 lb. of alum and ¼ lb. of common salt to each gallon of warm water. In this they should remain for about two days until thoroughly permeated, a condition which can be ascertained by bending a portion of the skin sharply between the finger and thumb, and observing whether a white line occurs, an indication that the action of the preservative is completed. Skins thus treated should immediately be stretched, either on the frame or some convenient flat surface by means of galvanised wire nails.

There are numerous modifications of the alum and salt treatment. Montagu Browne recommended the use of burnt alum and saltpetre (4 parts of the former to 1 part of the latter), mixed with sufficient water to form a paste, to be employed for direct application when mammal skins are to be mounted immediately. This preservative produces good white leather if kept continually moistened whilst the skins are under treatment.

Modifications of the Tawing Treatment.—With skins which have been cured in the field by means of dry earth, or simply sun-dried without any preservative, it is well to add a quantity of bran or oatmeal to the alum bath some days before use. This addition causes the liquid to become fermented, with the result that otherwise stubborn skins become fairly workable. Colonel Park suggested the use of a mixture composed of ½ lb. of salt, 1 oz. of good sulphuric acid, and 3 qt. of soft water, in which the skins of small animals may be immersed for about thirty minutes, and finally wrung out and hung up to dry.

An American method, but one that cannot be altogether recommended, consists in treating the skins of small animals with a strong lye of wood-ash until the gluten is destroyed, and then applying sperm or lard oil until the tissue is thoroughly permeated. This is perhaps one of the most rapid forms of treatment, it being possible to dress a calf skin in about half an hour; but extreme care must be exercised to prevent a too prolonged use of the lye destroying the actual tissue of the skin.

Destroying Fat in Fatty Skins.—Certain skins when freshly stripped from

the body are extremely fat, and no amount of scraping appears to render them entirely clean. Now, unless the actual surface of the skin itself is exposed to the action of the preservative, curing will be incomplete, and decomposition may set in, with the result that the hair or fur will slide in places, entirely marring the appearance of the whole. Washing the skin in weak lye for a short time will have the effect of saponifying the greater part of the grease; and if the skin be laid out, covered with bran or sawdust, and then thoroughly scraped, the operation being repeated if necessary, the surface will be rendered sufficiently permeable for the curing agents to enter. Salts of tartar and powdered rock ammonia in equal quantity, well rubbed in and allowed to stand for a little time, will effectually destroy small quantities of fat; but the alum and salt solution with bran or oatmeal added to it is practically as good.

Cleaning after Tawing.—Skins that have been passed through a liquid preservative should be well washed in several changes, preferably of tepid water, in order to remove all traces of the hydroscopic materials which enter into the composition of the cure before they are curried. Sometimes, however, such treatment is insufficient to render the hair completely clean, and one of the following methods should be employed. The hair may be saturated with benzolene or petrol (two highly inflammable liquids, which should in no circumstance be used in proximity to artificial unprotected light), and rubbed in its natural trend with a piece of flannel, the spirit being finally absorbed together with the greater proportion of dirt by means of sawdust applied in handfuls and afterwards beaten out.

Washing Skins.—Sometimes it is necessary to wash a skin, and for this purpose a strong soap solution, prepared either with powdered castile soap or one of the dry extracts of soap, should be employed. The skin may be laid on a table and rubbed with the liquid, applied by means of a piece of flannel or pad of cotton-wool, tepid water being used, followed by a plentiful rinsing with cold water. A little laundry blue added to the final change of water will enhance the purity of a white skin.

Tanning.—The methods already described are those principally in vogue amongst skin-dressers for the production of white leather; but before passing to a description of the final process of "currying," a few words may be said with reference to tanning. This means of preservation may be adopted with advantage in the case of certain small skins, in which the brown tinting of the hair by the tan is a matter of no consequence. A solution of tan may be made by boiling oak bark or oak galls in an iron pot with rainwater for about three or four hours, the water being renewed as it boils away. The resulting liquor should be allowed to cool completely before use, and the freshly stripped skins immersed in it for about a week, being taken out occasionally and rubbed.

Currying.—As previously stated, the success of any form of skin dressing depends entirely on the thoroughness with which the final stage of treatment known as currying is performed. In the freshly stripped skin the top surface, or inner skin, so to speak, locks up the more or less elastic and permeable under tissue into which the hair, fur, or wool is rooted. This, to a certain extent, is removed during the operation of fleshing; but in the first stages of currying it should be entirely cleared away. The whole of the surface, therefore, requires reduction, in the case of a large skin by means of the horse and shaver, and with one of small or moderate size with the shave-hook or the blade of a moderately sharp knife held obliquely and used with a scraping motion. When this top surface has been removed the under skin, if properly cured in the tawing process, will come up perfectly white and clean, and the tool marks may then be obliterated by means of pumice-stone or the glasspapering block. Small skins may be curried solely by being worked backwards and forwards across the block held in a vice.

Currying should be performed while the skin is still in a semi-moist condition, and after the first operation of reducing the

top surface has been thoroughly performed it should be subjected to vigorous pulling, rubbing, and beating until it becomes thoroughly supple. Working between the knuckles will generally suffie to entirely reduce a skin of small size; but others of larger proportions may be hung up and well beaten with a heavy stick. Such treatment will generally be sufficient in all skins which have been tawed whilst in a green condition; but others which have been sent home from abroad, after being sun-dried or earth cured, may require to be "greased." This operation consists in folding the skin together, hair outwards, into the form of a bag and sewing it up with a few wide stitches. Before all three edges are joined, however a pound or two of lard is introduced into the interior, and this is forced into the substance of the skin by pressure. Trampling on the skin with the bare feet is an effective means adopted by professionals; but the use of a mallet or laundry "dolly peg" may be recommended as an alternative. The grease should be allowed to remain for a day or two within the skin, and finally removed by scraping and the liberal use of sawdust or bran.

Mounting Skins.—A few words may be said with reference to the mounting of skins for ornamental mats and rugs. In the first place, the edges will require trimming, and this may be performed by means of a sharp knife or scissors. A backing should then be made up of fine canvas or a somewhat similar material known as crash. This should have the edges hemmed, and be cut to the exact outline of the skin itself. A border of blue melton cloth or baize should then be added, and this should be scalloped on the margin. This continuous border should be attached to the backing before the skin is mounted, this final operation being carried out by means of wide stitches with packthread.

Mounting Maps

Mounting a Map on Linen.—Suitable linen or fine canvas for mounting maps can be obtained from any drapery store; it goes by various names, such as butter muslin, cheese cloth, filled linen, and is a thin material filled up with a white, chalky preparation having a glazed surface. It may be possible to obtain it in one piece, but, if not, it may be joined temporarily by stitching; the exact method does not matter.

Having obtained the linen, lay it down on a floor or deal table-top, and drive in tacks along two sides at right angles (only drive the tacks far enough to hold it tight). Then tack down the other sides, and, whilst doing so, stretch the cloth as tightly as possible. Of course, the cloth must be a few inches larger than the map each way. Now prepare some flour paste, and paste the map carefully all over. Then lay it down on the cloth, taking care that no wrinkles are allowed to form, and rub carefully into contact, placing a piece of clean paper between the map and the hands. This must be carefully done, as the damp of the paste will have softened the water colour (if any), and it may run or blur. When this has been done, it may be covered up and allowed to dry.

After drying it must be sized with paper size, which can be prepared by boiling scraps of parchment. The size is applied with a brush, and there may be great difficulty in preventing the colours from running.

After the sizing is dry the varnish may be applied. The varnish necessary is a spirit varnish, obtained from a drysalter, who will also supply the size. The size and varnish are applied with a large, flat brush. When dry the tacks are drawn out, the map lifted, and the cloth trimmed

away from the edges with scissors. It may be turned over, and any temporary stitching removed from the cloth.

Mounting a Cycle Road Map.—The following is an excellent method of mounting a cyclist's road map, so that it can be carried in the waistcoat pocket. It is presumed that the map measures 22 in. by 17 in. after being trimmed. It should first be ascertained if the margin round the border of the map is even all round; if not, take a pair of compasses, a knife, and straightedge, and square up the map. Next procure from a local draper a piece of white calico 2 in. larger all round than the map to be mounted.

The map is next cut into sections as in Fig. 1. The best way of dividing the map is with a pair of compasses. Divide the space between A and B into eight equal parts. Mark the spaces at the top and bottom of the sheet, and with the knife and straightedge cut the map into strips. Next divide the strips into four equal spaces, to correspond with A to C, so that after cutting through these latter marks, the map will be in thirty-two sections, and if laid out will appear as in Fig. 1. Then stretch the calico tightly on a smooth drawing board or kitchen table, fixing it round the edges with tacks or drawing pins so that no wrinkles are seen.

The sections should be laid out in their proper order previous to pasting. Take the section marked No. 1 in Fig. 1, lay it face downwards on a scrap of paper, and apply a fairly good coating of flour paste. Each section should, after being pasted, be allowed to soak for a few minutes. When section No. 1 has soaked sufficiently, place it in position on the calico and give it a good rubbing with the palm of the hand. The remaining sections should be treated in the same manner, excepting that between the sections from A to B (Fig. 2) a space of $\frac{5}{32}$ in. must be left, while between the sections A to C a space of $\frac{1}{4}$ in. bare must be left. These spaces are to enable the map, when completely mounted, to be folded up. Any paste that sets on the face of the sections can be washed off with a damp sponge. The map, after being mounted, should be allowed to dry for at least twelve hours; it can be removed by cutting round the outer edge with a knife and straightedge, and should afterwards be folded up.

Making a Small Thumb Case.—To complete the usefulness of this map a small thumb case should be made as shown at Figs. 3 and 4. The skeleton of the case consists of a piece of white pasteboard of medium thickness (say, 3 or 4 sheet thickness), which should be about $\frac{1}{2}$ in. larger all round than sections 1 and 2

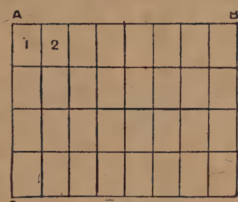


Fig. 1.—Dividing the Map for Cutting

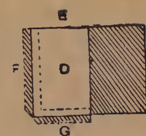


Fig. 3.—Pattern for Thumb Case


Fig. 4.—Map Thumb Case

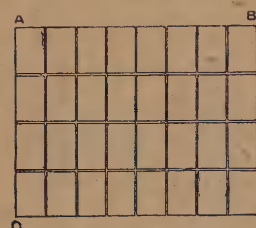


Fig. 2.—Mounting the Map in Sections

(Fig. 1). Fold the pasteboard in half, care being taken that the folding does not split the board at the fold. Take the map, which should be folded to the size of one section, place it inside the folded pasteboard, and mark the pasteboard with a pencil so as to allow the pasteboard to be $\frac{1}{4}$ in. larger all round than the map. The skeleton of the thumb case when cut down to these marks will be ready for the outer covering.

The best material for the outer covering of the case is a piece of paste grain roan, which can be procured from a local bookbinder, and should be about $\frac{3}{4}$ in. larger all round than the skeleton. The roan should

be cut to the shape of Fig. 3, the shaded portion representing the leather, while the light portion D represents the folded pasteboard. When the leather is cut to shape as shown by the shaded portion in Fig. 3, it should be carefully pared all round the edges, except the top edge E, and then pasted all over the wrong side. After a few minutes it can be placed in position as shown in Fig. 3.

The turn-in portions F and G should next be folded to the dotted lines, care being taken that a neat corner is made. The side H should be brought over and carefully rubbed down in position, but care must be taken that the leather in its soft and moist condition is not rubbed too much, or the grain of the leather will be taken out.

The thumb case should now be allowed to dry for a few hours, when the top edge E can be trimmed with a knife and straightedge. Then with a gouge cut out a thumbhole on the top edge as shown in Fig. 4, so as to facilitate the removal of the map. Should a gouge not be available, cut out a triangular piece. The thumb case should next be washed with a wet sponge and a little paste, and when dry it can be varnished with bookbinder's spirit varnish applied with a piece of cotton-wool.

Recess-headed Screws

THE illustration below shows the recess-headed screw and square-ended screwdriver. The fact that a screwdriver is an internal spanner becomes very evident when using this new type of driver. The square-ended driver fits snugly the square recess in the head of the screw, and its grip is comparable with that of a correctly shaped spanner upon a square nut, only the action is internal instead of external. Simple experiment shows that it is impossible for the new form of driver to slip from the screw-head, and that greater power can be safely and more easily exerted in using it. The possibility of fracturing the head of a recess screw is remote, and the chance of the tool slipping and scratching the work ought never to occur.

Furthermore, owing to the fact that the screw will stay on the head of the driver in any position owing to the friction between them, a screw can be inserted in an awkward place with one hand only, it not being essential to hold the screw in its place with the other hand when starting it in its hole.

Another advantage is apparent when withdrawing a recess-headed screw, as the internal-spanner action being so much more efficient than in the case of a slotted screw, it is not necessary to apply so much —or any—downward pressure. While it is obvious that the downward pressure necessary to hold the ordinary form of screwdriver in the slot assists in driving the screw into the work, that same downward pressure, or some part of it, is still necessary to hold the tool in position when *withdrawing* the screw, and we have then the anomaly that we are actually pushing the screw in a direction opposite to that in which we wish it to move. With the new screwdriver this does not apply, as in withdrawing the screw no downward pressure at all is necessary. These recess-headed screws have many applications and advantages for domestic use, and are obtainable in all the usual sizes.

A Recess-headed Screw and Square-ended Screwdriver

Hardening and Tempering Steel

If a piece of steel be heated to a cherry red and suddenly quenched in cold water, it will become exceedingly hard, while a piece of iron treated in the same way will be found very little, if any, harder than before. Practically all tools made of steel must be hardened and tempered. Hardening, itself, consists in heating the steel to a cherry red and then suddenly quenching in cold water, as already explained. The steel is now hard enough to scratch glass, but it is also very brittle and quite unsuitable for use in tools, because it would easily chip or break. Consequently, the steel must be tempered or softened a little. This operation is performed by a second heating to a definite temperature, not so high as before, and again quenching. Different tools require different temperatures for this second heating, and the art of tempering lies in knowing when the metal is at the right temperature. This can be approximately found without thermometers by means of the colours of a film of oxide which forms on the surface of the steel, or by heating the tool in a bath of a known temperature, such as an alloy at its melting point.

The beginner should harden a piece of steel and, after polishing one face with emery-paper, place it on a piece of red-hot iron, such as a poker, and notice the changes in colour as the steel gets hotter and hotter. At first the polished part will turn a pale yellow, which gradually deepens in shade, the yellow getting redder until it becomes purple and finally blue. When the worker can recognise these colours he can start tempering. Most tools require to be of different tempers in different parts. The cutting edges are usually fairly hard, while the remainder should be left fairly soft, in order to prevent fracture caused by the strain of percussion or torsion.

Chisels.—The simplest tool to temper is a chisel. Now the cutting edge should be a bright yellow, while the remainder is left soft. The chisel should be heated to cherry red and about an inch of the cutting end should be plunged into cold water. This hardens the end, the shaft being kept soft. Now polish the bevel of the chisel by rubbing on a brick or by means of the grindstone. The shaft of the chisel is still at a dull red heat, and this heats up the last inch or so. When this last inch, or rather, the cutting edge, is a bright yellow, plunge the whole of the tool into cold water.

Drills, etc.—Very small articles, such as tiny drills, are difficult to harden with a fire because they are so easily lost amongst the coals. They should be made red-hot in the flame of a candle and then plunged into grease to cool them, and will then be of the right temper. This method is only suitable for the small drills used in archimedean drills.

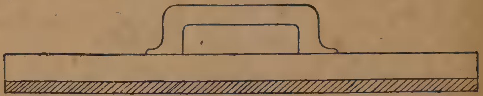
The following is a good method of tempering such articles as large drills,

Class of Tool	I *Tempering Colours*	II *Temperature*	III *Suitable bath*
Metal working tools	Cutting edges yellow of the same shade as singed linen	450° F.	Flashing point of tallow or an alloy of tin 1 part, lead 2 parts at its melting point
Wood working tools	Cutting edges a dark yellow or clayey colour	500° F.	An alloy of tin 1 part, lead 5 parts
Saws for wood	Bright blue	55° F.	An alloy of tin 1 part, lead 12 parts
Springs	Dark blue	600° F.	Boiling linseed oil.

taps, reamers, etc. It is rather an unpleasant operation, but it gives splendid results. Plug up a piece of gas piping and fill it with the articles to be tempered. Heat the tube in the fire until the contents are judged to be a bright cherry red. This will usually be a few minutes after the tube is red-hot. Shake the articles out of the tube into a bucket of water, keeping the end of the tube close to the surface of the water. Some workers add a handful of salt to the water, and pour a little sweet oil on the surface until the water is covered; but this is not essential. Take out the articles and dry them well, dry sawdust being very useful for this purpose. Now take an iron box, a frying-pan, or pudding dish, in fact any iron box which is not soldered but made of one piece of metal. About half fill this box with tallow candles, and melt them over a clear fire. It is better to perform this operation in the open, and a little fire-place can easily be made with a few old bricks. When the tallow is melted, drop the tools in and stir, until a blue flame begins to flicker over the surface of the grease. When this happens pour the contents into a bucket of water.

The grease can be skimmed off and used again. The tools will be of a light brown colour and no attempt should be made to let the shafts down to a lower temper. This method may be extended to nearly all tools, but the cooking bath must be at the proper temperature. Column 1 of the preceding table gives the colours for various tools, while column 3 gives suitable baths for tempering. If a molten alloy is used, care must be taken that it is not thrown up into the worker's face when it is poured into water.

Saws.—Thin sheets of steel such as saws are rather difficult to temper, because they tend to buckle up or crack when plunged. In factories, they are cooled by laying between sheets of cold iron, but the best way for the amateur is to cool them by laying the red-hot steel between two boards which have wet cloths stretched over them. The top board should have a handle, as in the



Board for Cooling Saw Blades

illustration, so that it can be quickly placed upon the metal.

If the teeth of hack-saws are of the proper hardness the saws themselves often break very easily, but this may be overcome by having the backs soft. Place the teeth and about $\frac{1}{16}$ in. beyond them between two pieces of cold iron, and warm the rest of the saw with a gas flame or lay a hot poker along the saw for a short time.

Case-hardening.—The principle of hardening and tempering is not yet fully understood. There is no chemical change; the changes in the hardness of the steel are due to physical actions, the sudden lowering of temperature causing a molecular change as yet only partly understood. Iron cannot be hardened in the same way as steel, but by means of a surface carbonising process it is possible to change the surface of the iron into steel that can be hardened. This process is termed case-hardening. Make the iron red-hot and roll it in powdered yellow prussiate of

potash, return the iron to the fire until the potash becomes creamy, then plunge into cold water. If any part of the iron is required soft, that part should not be covered with the potash. Care must be taken not to inhale the fumes which come from the potash as they are very poisonous.

There is another method of case-hardening, this possessing the advantages of being cheaper and enabling a number of articles to be done at the same time; but it is rather an unpleasant operation. First obtain a supply of animal charcoal; this can easily be obtained by burning scraps of animal matter, such as old bones, scraps of leather, etc. Now obtain an iron box —this need not be in one piece, but the joints must be folded and not soldered. Place a layer of the charcoal in the box and then fill up with the articles, packing them well with the charcoal. If any parts are required soft, wrap them round with clay. Raise the box and its contents to a bright red heat and then remove the articles and plunge them into urine. This method usually requires a forge, because a large fire is needed to heat up the box.

The principle of case-hardening is a combination of the iron with carbon, forming steel which, being quenched, is hardened in the ordinary way. The carbon is obtained from the prussiate or from the urea.

It is not possible to make tools of iron which is afterwards case-hardened, its skin of steel being next tempered, as this skin is very thin and would be worn off or burnt off during the second heating.

Large tools, such as axes and choppers, are sometimes made of case-hardened iron. These are left hard, no attempt being made to temper them. If a chopper gets very dull, soften it in the fire, file the edge sharp and smooth, and case-harden. It is only the cheapest tools, though, that are made in this way.

The chief use of case-hardened iron or mild steel is for articles that require a hard surface but must be fibrous underneath, such as bearings. Steel is quite unsuitable for these articles because, if left soft, and consequently tough, they would soon wear away or could be easily filed in two, while, if hardened, they would be brittle and unable to stand much strain. Mild steel cannot be hardened or tempered, but can be case-hardened, giving much better results than case-hardened iron.

Remedying Loose Screws and Casters

Trouble often arises from screws that are loose in their holes. Generally there has been a side pull or wrenching action on the metal fittings or other fixtures attached by the screws, with the result that the screws are moved sideways and thus enlarge the holes in the wood. An obvious remedy is to insert thicker screws, but this is not always possible; perhaps thicker screws are unsuitable for the fitting. A little trick which is thoroughly reliable is to insert in the screw-hole a Rawlplug, which consists of a little tube or sleeve of jute. It is simply pushed in with the fingers, the fitting re-erected and a good new screw, not thicker than the original one, inserted in the ordinary way. The plug is compressed by the entering screw and gets a good grip in its hole. It may, or may not, be necessary first to clear the hole out with a gimlet or coarse bradawl before inserting the Rawlplug.

This trick answers very well in the case of casters which have to stand very arduous work. In course of time, caster screws often get wrenched out of the end-grain wood. The old remedy was to fit a glued wooden plug, but the use of the Rawlplug is a big improvement on that method.

Typewriter Adjustments and Repairs

THIS chapter has been specially written by a typewriter mechanic of thirty years' practical experience to meet the needs of people who wish to keep their own typewriters in good order. At the outset, it must be made plain that it is quite impossible to illustrate the hundreds upon hundreds of mechanical arrangements and details to be found in the many scores of different makes of typewriting machines now in use. In nearly every case an instruction book containing illustrations of the mechanism as a whole and of its component parts may be obtained, either free or at a small charge, from the makers of the machine, it being necessary when asking for it to quote the number that will be found stamped or engraved in a more or less prominent part of the machine. Study of the typewriter itself with the aid of the instruction book will put the reader in possession of the general principles upon which the machine operates, and he will then have no difficulty in the light of the following information in keeping his machine in first-rate condition. Much of the information in this chapter is now published for the first time, and, as every word is the result of long, practical experience, complete reliance may be placed upon the advice here given.

Most of the adjustments of a typewriter are comparatively simple once the underlying principles are understood. In the early days of the typewriting machine it was common for an expert to travel perhaps of scores miles to rectify, in most cases, small adjustments such as are explained in this section. Even to-day much the same applies, but typewriter mechanics are more numerous. A little simple knowledge will often save many hours of valuable time and expense.

Cleaning the Type.—Of great importance in the production of good writing is the state of the type. Dirty type cannot produce good writing. It is advisable to brush the type over once a day if the machine is in more or less constant work, and every now and then the types can be cleaned with benzine as explained below. If the dirt has been allowed to harden in the type a brush will not remove it, and it must be picked out with a pointed instrument (even a pin will do), afterwards cleaning with benzine. The author has known many cases in which people have given orders to have their machines fitted with new types throughout when all that was necessary was to give the types a thorough cleaning.

It is a very simple matter to clean the types. Simply rub them with a toothbrush, and, if the types have been neglected, first dip the brush lightly into benzine. Then, providing the ribbon is reasonably new and clean (or, as the case may be, the pad good and clean), the writing will be clear. Benzine is obtainable from chemists in small quantities, and should not be used near an open flame or fire. The benzine has a solvent action on most things, and care should be taken that it does not splash on to the

keyboard, to prevent which it is well to cover up the keyboard with a cloth. It will be found that the benzine soon evaporates from the types and leaves them as clean as when they were new. Benzine can be used also for cleaning other parts of the machine, using a long-handled soft brush for the purpose. It rapidly dissolves any dirty oil adhering to any part of the mechanism.

The Ribbon Mechanism.—In using a typewriter it is important not to leave both of the ribbon spools empty at the same time, as in many machines the reversing gear may then get locked and stop the working. This means that it is wise to leave the old ribbon on one of the spools until the new one has been placed on the other spool; then the old ribbon can be removed and the new one connected up in the ordinary way.

Wherever there is friction on the ribbon shafts they should be well oiled to ensure free running.

In most makes of machines the ribbon movement is driven by the travelling of the carriage, and, therefore, should the ribbon movement be sluggish it may prevent the carriage from travelling at its proper speed; in other words, if the ribbon-movement mechanism becomes stopped the carriage is bound to stop with it.

Separation of the small cog wheels frequently gives rise to ribbon trouble, and it therefore follows that whenever the ribbon fails to travel properly, or whenever it becomes stopped and the types strike it in the same place one after the other, it is advisable in the first place to make quite sure that the ribbon cogs are meeting properly. Usually these cogs are fastened in position by small screws which are apt to become loose with vibration, the cogs then separating and the ribbon movement becoming useless. It is a simple trouble to locate and rectify, all that is necessary being to place the loose cog in such a position that it meets the corresponding cog and then to tighten the screw. This is one of the principal parts of the ribbon-actuating gear.

The ribbon-gear pawls should be closely watched in a case of ribbon trouble. Generally they are found working on a ratchet wheel near the mainspring box. If these pawls get sluggish they will not fall properly into the teeth of the wheel, the ribbon movement being prevented from acting. The remedy is to drop a little oil on to the pivot or screw that holds the pawl in position.

When a ribbon stops working, the operator should most carefully examine the places above mentioned, and a little thought should then make plain the necessary corrections and adjustments.

The Ribbon-throw.—This piece of mechanism which is fitted to most visible writers is designed to bring the ribbon to the proper point where it should receive the type, and afterwards fall out of the way so as to enable the writing to be visible immediately the letter has been printed. Occasionally the ribbon-throw will get sluggish and stiff, and should it stop up altogether it will hide the writing from view. Such a difficulty may be caused by a slight bending, but in most cases the trouble is that the slides have been allowed to get dry. When this trouble arises first try the effect of a very small drop of oil on the slide or slides upon which the ribbon-throw works. Do not use too much oil as it will get on the ribbon and spoil it. Immediately the ribbon-throw works freely, wipe off any superfluous oil. In nine cases out of ten this oiling will effect a cure; where it does not, the part has had a knock and been bent and some time may be spent in getting it right, as the operator must find out very carefully where the bend is and alter it accordingly—a rather delicate operation calling for much patience.

Paper-feeding Mechanism.—The paper-feeding mechanism is similar on most machines, and, as operators know, when it goes wrong it is a nuisance and the cause of much lost time. At the first occurrence of the paper going crooked it should be attended to, as otherwise it invariably gets worse and becomes serious. At the very first notice of paper-feed trouble a little wood naphtha rubbed on the main cylinder (or platen, as it is

usually termed) will in most cases rectify the trouble. It is only a matter of removing the gloss or polish that accrues on the outside of the roller. Rubbing on the wood naphtha with an ordinary cloth usually has the desired effect. It is not generally known that a glossy cylinder is the cause of most paper-feed trouble, but a little thought in this direction will prove to most persons that if the roller fails to carry at one side and not on the other, the grip on the paper must be at fault, the cylinder being perhaps more glossy at one end than the other. The same applies to the feed rollers, but not so much as to the main roller. Wood naphtha can be obtained in small quantities from the chemist, and as it is highly inflammable it must be kept from a naked flame or fire.

The above applies to cylinders in otherwise new condition, not to old, hard cylinders which are out of truth.

The Spacing Mechanism—the Escapement.—What is probably the most important part of a typewriter is what is known as the escapement; usually it is at the back of the machine, and it comprises a small toothed-wheel—the escapement wheel—and two small parts known as spacing dogs, of which one is a fixture and the other moves in and out, the distance by which it moves being less than the spaces between the teeth of the escapement wheel. This mechanism determines the spaces between the letters. When a key is depressed the spacing dogs are set in motion and give one space every time they go in and out of the escapement wheel. The loose dog springs out just sufficiently to allow one tooth to pass, and it fits into the next tooth. This can be easily understood, because if both of the spacing dogs were fixed they would work in and out of the same tooth every time and they would fail to give the space.

In fact, sometimes the loose dog does become fixed, mostly from the want of a drop of oil, and then the spacing mechanism fails. Keeping the escapement wheel well lubricated will prevent wear and assist the dogs in their proper action.

Should the letters begin to write on top of one another—a common complaint—the first part to be looked to is the escapement, and very often a complete remedy is simply lubrication, the dry escapement wheel not giving the spacing dogs a chance to get in and out of the wheel teeth quickly enough. As these parts are in action every time a key is struck, it is well to see that they are kept well lubricated.

The Carriage.—The next most important point is the run of the carriage. If this is at fault the writing will be irregular and, indeed, it is a frequent cause of irregularity. If the carriage is allowed to get sluggish the first result will be that the letters will tend to run into one another, and if the trouble is not then rectified the carriage will eventually stop altogether. The remedy is simple, being in most cases merely the application of a little oil. For all purposes of typewriter lubrication only the best typewriter oil — a refined oil supplied specially for the purpose—should be used. When typewriter oil is unobtainable, watch-maker's oil, obtainable from any watch and clock-maker, should be used. On no account use thick lubricating oil, as it is liable to clog and leave the machine in a state which might be beyond the amateur's skill to rectify.

The construction of machines differs, but a little study of the running of the carriage will enable most people to locate where the oil should have effect. For instance, some machines run on ball-bearings, others on roller bearings, and others on circular rods and wheels. Take the Underwood machine as an example; its carriage runs on a tight-fitting rod at the back of the machine. Oiling this rod occasionally (not too liberally) invariably keeps the carriage running smoothly. Some of the Remington models and other well-known makes are constructed in a similar manner. It should be easy to remember that where a typewriter carriage runs on rods those rods should not be allowed to get dry, otherwise there will undoubtedly be trouble. A good way is to have a greasy rag at hand and wipe them over occasionally, and this will save

the splashing caused by the use of an oil-can on these particular parts.

Most rod machines have also wheels which run on some of the rods but not on all of them. These wheels require occasional attention, and if only one of them stops revolving from the want of oil, it will wear a flat part and throw the whole carriage out of gear and will also alter the seating of the carriage and affect the alignment of the writing, as the carriage could not be in the proper place to receive the type at the printing point. All this can be obviated quite easily by dropping a little oil (only occasionally) on the pivot or screw which holds the wheel in position. The oil should not be dropped exactly on the wheel, but down the sides, so as to reach the pivot on which the wheel revolves. On various machines a small hole is drilled in the wheel so as to allow the oil to pass through on to the pivot in this manner, but failing this it can be effected by oiling in the manner above explained.

In the case of machines with roller or ball bearings, the carriage does not require so much attention, but the ball or roller races should not be allowed to get dry.

In general, a small greasy cloth is useful. A wipe over the important surfaces takes only a minute and ensures a free-running carriage and naturally saves the bearings from unnecessary wear. With the carriage rods properly greased and the carriage wheels revolving freely, a lot of trouble will be obviated.

When the Carriage Stops Suddenly.—This trouble may result from different causes, such as the paper guides getting strained or bent, and catching against something in their progress. In the case of visible-writing machines this can usually be seen by moving the carriage very gently to the point where it may be catching. In the other class of machines the repairer can usually locate where the carriage may be catching by moving it up and down gently in its natural position by means of the release key, and carefully watching underneath the carriage from the sides of the machine. On most machines there is room for a proper view between the top of the machine and the bottom of the carriage to enable one to see what the obstruction may be.

The Draw-band between Carriage and Mainspring.—If the foregoing instructions are carried out there is not much fear of breakages, but sometimes these happen even on new machines. So far as the carriage is concerned, one of the most important working parts is the draw-band that connects the carriage to the mainspring. As there is a continual strain upon this it breaks perhaps more frequently than any other part of a typewriter, for which reason various devices are in use, the most universally used being a narrow band of steel or strong tape.

Most makers build their machines so that the carriage draw-band can be easily fitted, but in cases where a spare draw-band is not at hand, it is not generally known that there is room for making a simple joint which is quite strong, although the appearance suffers.

A small brass paper-fastener is sufficient to join any carriage draw-band, either steel or tape. It is only necessary to make a small hole near the break on each of the pieces, overlap them and place the fastener through the two holes and bend the prongs over. Some machines have draw-bands in the shape of a thin chain, and others have a thin cord similar to cat-gut. In these cases the joining may be a little more difficult, but, nevertheless, it can be well effected. There is room enough to allow of the two broken ends being overlapped and, this having been done, they should be bound with a piece of thin copper or brass wire. Where this cannot be done, a piece of really good twine can be used as a draw-band and this will last a surprisingly long time.

Adjusting the Carriage Tension.—In a new machine the tension should not need to be touched, but in course of time some adjustment will become necessary. The adjustment is a simple matter, and almost any typist can tighten up the tension without any mechanical knowledge whatever. But it needs to be pointed out that tightening up the carriage tension

too much conveys no benefit whatever; it makes the carriage harder to press back, and even if the carriage does go along more quickly it by no means proves that the typist is writing more quickly. In a new machine when the carriage tension is accurately adjusted the carriage comes steadily along as the keys are worked, and receives the type in the proper position even for the fastest operator, although as a matter of fact, the main spring will wind up to nearly twice its normal tension so as to pull the carriage along nearly twice as quickly, but the spring is not meant to be treated in this way, and the extra tension is only a reserve to allow of the spring being tightened up from time to time as the machine shows signs of wear.

Moreover, the higher the tension of the carriage the more liable it is to break the escapement wheel or the spacing dogs, which are made of very hard metal and are liable to snap if called upon to do too heavy work.

The tension of the carriage should be only sufficient to carry it along according to the speed of the typist; thus a slow typist does not require so strong a tension as an expert who is attempting speed-record breaking, but even for the latter purpose the tension is not tightened up to the full extent by any means. The less the tension at which the carriage will work satisfactorily the better for the typist and for the working parts of the machine.

The best way of arriving at the happy medium is first to see that the carriage runs freely, apart from the spring tension; the rods of the carriage may need oiling as they often do, and should they get completely dry the whole strength of the main-spring will not be enough to pull the carriage along. This point is mentioned because the typewriter mechanic discovers these conditions every day. It is useless to tighten the main-spring for the purpose of pulling along a carriage which to all intents and purposes is stuck on the carriage rails.

Having obtained a freely running carriage, proceed to tighten up the main-spring just sufficiently to pull the carriage along at the desired speed and no more. If the tension is too low, the letters will run into one another; in other words, the carriage will not get away quickly enough to receive the next letter. Then tighten up the tension a little more, but not enough to put an unnecessary strain upon the working parts of the machine.

Adjusting the Key Tension.—The key tension is adjusted by turning a nut or screw which tightens up a spring. Much of the information given under the heading of carriage tension applies in this case, although with certain differences. The adjustment needs to hit the happy medium, neither too tight nor too loose; but in this case the tendency of the typist is frequently to loosen the tension excessively with the object of obtaining a light touch, the result being that the speed of the machine is interfered with, and the letters are liable to skip. As far as accurate working of the machine is concerned, the tighter the key tension is the better, but an excessively tight tension means undue wear owing to the heavy depression of the keys which the tight tension naturally involves.

Should the typist consider that the keys are too hard to press down according to his touch, the key tension may be slackened, just slightly, then tested by writing as quickly as possible, and should everything be in order leave well alone; should, however, the letters skip or jump the tension is too slack, and the only course is to tighten it up slightly and try again. Most standard machines have a key-tension adjusting screw in a prominent position mostly near the centre of the back of the machine or underneath it, sometimes in front. If in doubt as to its position, first look at the escapement wheel (the part where the spacing dogs function to produce the letter spaces), and in its neighbourhood will be found a spring—the key tension spring—with an adjusting screw. It occasionally happens, in the case of a machine that has had a fair amount of wear, that the tension spring may have become so weak as to be useless, even with the adjusting screw tightened to the utmost. When

this is so, the trouble can usually be remedied by removing the spring and cutting off a few of its coils, the shorter spring having a stronger action when re-inserted. If the fingers cannot reach the spring it may be possible to detach the spring by means of a bent wire with which the spring can be hooked on or off. In replacing the spring, loosen the adjusting screw as far as it will go without falling out, attach the spring and tighten the tension in accordance with the instructions already given.

Adjusting the Shift-key Tension.— In machines having a shift-key this will be found to have an adjustable tension similar to the key-tension spring but larger and stronger because its work is heavier. When it gets loose by stretching, as it will do after a time, the capital letters will get out of alignment with the small letters owing to the carriage not getting back into position quickly enough to receive the small letter after the capital has been struck. Therefore, the spring must be tightened much in the same way as the key-tension spring already dealt with. On some up-to-date machines a special form of adjustment for this shift-key tension is provided. It takes the form of a little stand containing little cuts or slots, the idea being that when the spring fails to act quickly enough it should be disconnected and then connected on to the next slot, or perhaps the one next to that. As in the case of all the other tensions it is most important not to overdo this tightening, otherwise an unnecessary strain will be placed upon the carriage. It is nearly always found that quite a slight alteration of the tension answers the purpose in the case of any one of the three tension springs here dealt with.

On some machines the shift-key moves the type-bar segment instead of the carriage, but the tension spring is there just the same. It must, however, be noted, and can be easily understood, that in some machines this spring must be tightened to obtain a quicker action, whereas in other machines it must be loosened, and tightened if coming back too quick. In other words, on some machines this spring pulls back the carriage whilst in others it prevents the carriage from going back to position too quickly and imposing heavy and unnecessary wear.

Alignment of the Type.— Faulty alignment is usually left for the expert to put right, it being quite easy for an inexperienced person to do far more harm than good in trying to rectify it. However, with care and practice, a great deal can be done. In some machines, such as the Remington, there is in each type-bar an adjusting screw, and by altering this very slightly indeed the type can be brought to the proper printing point. For example, should any particular letter print below the others, slightly loosen the type-bar hanger screw and gently tap the type-bar or lift it up to the desired point, afterwards tightening up the screw again so that the type-bar will remain in position.

Of course, if a letter strikes or prints above the line, the remedy is to loosen the hanger screw, tap the type-bar down as required and re-tighten the screw.

Sometimes a letter will get too close to the others, although the alignment may be perfect. The remedy is to move the type-bar to the left or right, as the case may be, and this, of course, is obvious. The actual execution of the adjustment may take some little time but the work is worth doing.

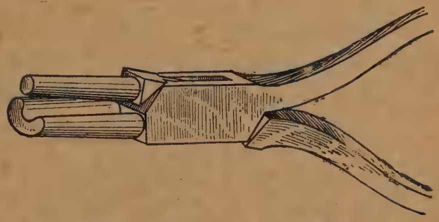


Fig. 1.—Simple Type of Alignment-adjusting Tool

Alignment-adjusting Tools.— Although type-bars and types can be twisted by means of a pair of ordinary pliers (far more safely, be it said, with *two*

pairs of pliers) this tool is not always an ideal one for such a purpose, particularly as regards the type-bars. A few years ago the tool generally used for giving a slight bend to a type-bar for the purpose of bringing the type into alignment was of the shape shown by Fig. 1. It will be understood that the top jaw of this special form of pliers applies pressure to the type-bar at a point between the two anvils of the bottom jaw, and by holding this tool in any desired way a bar can be bent up or down or to either side. This tool was found to have the disadvantage that it could not be used in many instances owing to the difficulty of using it in the particular direction required when inserted into the machine, and a far more convenient type, known as the "nine-prongs," was introduced. This is illustrated photographically in Figs. 2 and 3, and it will be readily understood that it is a multiple tool working on the principle illustrated by Fig. 1, but capable of being used vertically or horizontally to effect any alteration in a type-bar in any desired direction. This tool is regarded as being indispensable to the modern typewriter mechanic.

Adjusting Alignment: Tightening the Type-bars.—A type cannot be successfully put in alignment unless first of all its bar is made tight; in other words, there must be no play in the hanger or, at any rate, only the very slight play which an experienced typewriter mechanic will know how to judge. Of course, if the bar is too tight it will not swing freely, and that must be guarded against, but should the bar be too close it cannot possibly strike in the same spot every time, and therefore it would be a waste of time to put a type into accurate alignment if all the time the type-bar itself was shaky. A properly adjusted type-bar will deliver the type to exactly the same printing spot every time.

Fig. 4 is a sketch of a pattern of type-bar frequently met with. On most machines this type-bar can be easily removed for tightening so as to obviate the wear which accrues in the course of time. On other machines the type-bar can be tightened up without any necessity for removal. The idea is to close in the type-bar hanger A (Fig. 4) as much as possible without interfering with its freedom of action. To do this, when the type-bar has been removed from the machine, simply tighten the rivet B in the middle of the hanger by resting one end of it on a metal block and tapping the other end

Fig. 2

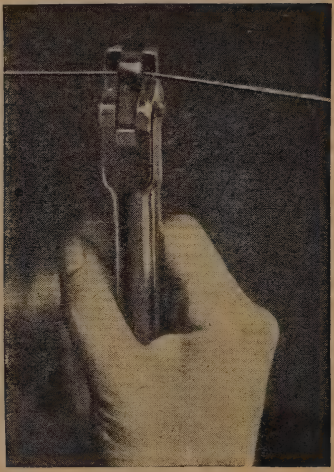


Fig. 3

Figs. 2 and 3.—"Nine-prongs" Tool for Adjusting Alignment

with a small hammer; but do not interfere with the front pivot C upon which the type-bar D itself swings. It is wrong to suppose, as some people do, that a type-bar should be tightened from its pivot C. In Fig. 4, D′ in dotted lines shows the position of the type-bar when at rest.

To tighten a bar which has not been removed from the machine (possible in some, but not all cases), it is essential to use a small tool having a slit just wide enough to fit on the side of the hanger between the rivet and the front of the hanger where the type-bar swings; this small tool is really a lever, and with it the hanger is slightly bent inwards so as to tighten the bar. It is easy to overdo this and tighten up the bar too much, and if this should occur the hanger must be opened up with a screwdriver. This kind of type-bar is held in position by one screw which in most cases is easily accessible.

In the case of type-bars which have adjusting screws it is a simple matter to tighten or loosen these at will, usually without taking the bar from the machine.

In many typewriters alignment depends upon what is usually termed a centre guide, and if the type-bars are too loose or bent they will be apt to hit upon the side of this guide.

It should be said that in some machines the type-bars are not intended to be tightened, but are made all in one piece so as to swing upon a rod through grooves just wide enough to allow of the type-bar moving freely.

The importance of using a little oil may be again referred to. On the type-bar illustrated by Fig. 4, the use of a little oil on each side of the hanger where the bar swings will prevent wear and ensure free swinging. It will also have a very considerable effect upon the "touch" of the machine.

Type-bars working in a groove will sometimes be found to get sluggish and liable to stick. Just a little oil will work wonders in cases of this kind.

Adjusting Alignment in Shift-key Machines.—There is no doubt that it is more difficult to remedy alignment in a shift-key machine than in a double-key-board machine. To be correct, the small letter written after a capital should, of course, be perfectly level with it, but in course of time the distance which the carriage moves when actuated by the shift-key becomes greater, thus throwing out what is called the carriage motion, that is, the capital and small letter together. On almost every shift-key machine there are adjusting screws and nuts to allow of taking up any wear resulting from the movement of the carriage. If the reader will experiment

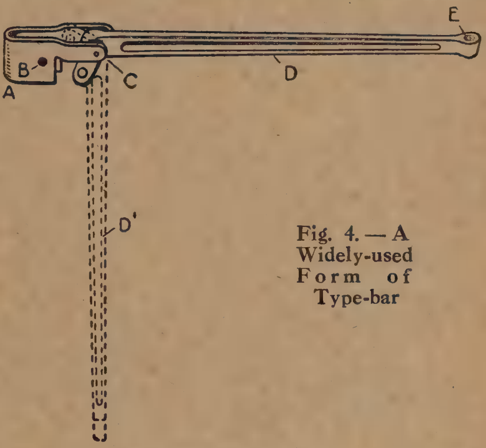


Fig. 4.—A Widely-used Form of Type-bar

with any machine and watch carefully the position of the carriage after the shift-key has been depressed, he will find that the carriage has been stopped by a screw or nut, or, in some machines, by a small plate. These are at each end of the carriage and are adjustable so that if the carriage goes too far when the shift-key is depressed, the screw or nut can be tightened, or the adjustable plate dropped accordingly. The same adjustments apply to the carriage when it falls back into position for the small letter after the capital has been printed.

Obviously the falling back of the carriage for the printing of the small letter will cause more wear than the shifting of the carriage for the printing of the capital letter; therefore, in most cases it is better to effect the adjustments when the carriage is in its normal position—that is,

in the position for printing the small letters. To illustrate what is meant by this, assume that the motion is entirely out. First get the capital letters in order by ensuring that they print cleanly and evenly top and bottom, and at both ends of the carriage. (By the way, it is usual to work with the letter "N.") If the capital letter is thin at the top or is thin at the bottom, this indicates that the type is not striking on the centre of the cylinder, and it will be necessary to tighten or loosen the adjusting screw, as the case may be. Having obtained a clean and even print of both, the rest is easy, all that is necessary being to tighten or loosen the adjusting screws governing the small letters so that these letters come exactly in line with the capital, thus n N n. (Although the letter "N" is generally used for this purpose it would not be wise to use it as a test letter if it happens to be worn more than the other letters.) It is now necessary to tighten up the nuts so as to keep the adjustment parts in their proper position. This applies, of course, in cases where there is an adjusting screw and nut, the idea being to get the screw into its proper position and to lock it there by tightening the nut.

There is a special point to watch in the case of shift-key machines, there being two types on the printing fount, the small and capital letters. It may happen that the capital letter is out of alignment in such a way as to show it out of centre on the right-hand side, while the small letter may be out of centre on the left-hand side. It may not be necessary in this case to move the type-bar at all, as the type itself has become twisted. To test this, first print the small letter, then the capital letter, and then the small letter again. Print these two characters one after another in line. If the type itself is twisted the writing will appear so: "Q q Q q Q q" or "Q q Q q Q q," instead of "Q q Q q Q q."

Twisted type can be remedied with an ordinary pair of pliers; the capital letter will come one way and the small letter the other, so that they are bound to meet in the centre if the adjustment is correct.

It must always be remembered that it takes but very little to twist or strain or even break some parts of a typewriter, and it is therefore necessary to exercise great care in one's first attempts, so that the worker can learn to judge how much effort is required to get the desired effect.

Fixing a Loose Type.—It is well to know how to fix permanently a troublesome loose type. Many machines have their types pressed into the hole E, made at the end of the type-bar shown in Fig. 4. Generally this method is quite satisfactory, but occasionally a type gets loose owing to the enlargement of the hole. Of course, a new type-bar would remedy the trouble, but this is not always necessary, as the use of a little solder will usually hold the type in position indefinitely, but it is most essential that the type be in its correct position on the type-bar before applying the solder, as once fixed it cannot be altered without melting out the solder and trying again.

Adjusting the Key-lever.—In some machines will be found an adjusting screw or nut right at the point where the key-lever comes into contact with what is called the universal bar. This is undoubtedly a good idea as it enables the operator to take up any wear arising at this important point. Obviously, the constant striking of the key-lever against the universal bar must make a difference in time, as both of these parts must become worn to some extent. Such letters as E (which is used far more than any other) will naturally wear out sooner than such letters as Y, Z, Q, etc., and it will then be seen that with the aid of the adjusters above referred to it is possible to correct any worn letter quite easily without interfering with the others, the correction being made simply by tightening the adjuster on the lever sufficiently to counteract the wear. It is easy to see when wear appears on these parts as the key-lever when worn will be liable to strike the universal too late and not pull the spacing dogs sufficiently to obtain the necessary space after the letter has been printed, in which case the next letter is printed on the top of the one before it.

Of course, when a machine has had a lot of wear, it may be necessary to tighten the universal bar itself to some slight extent, this having the same effect as adjusting the key-lever, except that tightening the universal bar at both of its ends acts upon all the keys.

It is most important for the reader to realise, before he starts any adjustments of this nature, that very careful work is called for as a very slight adjustment will make a lot of difference in the writing.

How the Key-lever Comb may Affect the Touch.—Underneath the typewriter, near the front, is a metal comb, in the divisions of which the key-levers move. Should for any reason the teeth of this comb get bent they will become so close together that a key-lever will bind or touch at one side when moved, not enough perhaps to prevent its working, but quite enough to prevent its doing so with perfect freedom. The teeth are easily bent and adjusted with an ordinary screwdriver. Each key-lever should have just a little play each side between the teeth.

It is interesting to see the difference which a touch of good typewriter oil on the key-levers at the places where they work in the comb will make to the touch. It is always worth the typist's time to examine this comb and to see that the key-levers are working as they should. As a matter of fact this is a part of the typewriter which the majority of typists never consider or even look at.

The Effect of a Worn Cylinder.—No machine can give good work if the cylinder or platen, as it is usually termed, is in bad order. A good platen is essential both to the appearance of each individual letter and to the feeding of the paper. Typewriter users commonly buy new ribbons, but they rarely think of fitting a new cylinder until the need is pointed out to them. But a new cylinder is not a costly fitting and, as a matter of fact, is economical inasmuch as it saves wear and tear on the ribbon.

A new, smooth cylinder obviously allows the type to give a clear impression with a minimum wear of the ribbon. An old cylinder is hard, generally out of truth, and the holes in it prevent good writing because when a type strikes the ribbon partly on one of these holes, only part of the type prints, at the same time producing a "patchy" effect and tending to cut the ribbon. This cutting effect may be only slight, but it will easily tend to wear out a ribbon in half the time it would last on a new machine, this being especially so in the case of inferior ribbons.

Then, in addition, a hard, glossy cylinder cannot be depended upon to feed the paper accurately as it may fail to grip the paper at one end or the other; indeed, if a cylinder were allowed to get glossy in every part it would not take the paper at all. It will thus be seen that it is advisable to have a new cylinder at the first sign of wear as the cost is not much, and the advantages are improved paper-feed, greatly improved appearance of the writing and reduced cost of ribbons. Typists are not aware, in general, of the fact that in most standard machines a new cylinder can be fitted in a few minutes.

Cylinder Knobs or Twirlers.—With the constant turning of the cylinder the knobs may become loose and lose their grip, a trouble easily put right by tightening a screw (perhaps two screws), which will be found on the sleeve of the knob. Should, however, these screws be tight and the trouble continue, it will be found that the shaft is loose. Look for a similar screw or screws at the left end of the cylinder (in some makes of machines these screws are at each end). Tightening these screws will obtain the grip when the knobs are turned.

Renewing Keyboard Letters.—On an old machine the keyboard letters may be dirty and worn, and these will affect both the pleasure and convenience of using the machine and will also lower the selling price. New keyboard letters can be fitted to most typewriters at quite a small cost. On many machines the actual letters are printed on paper or card and are covered with glass, the glass and letter being kept in position by what is called

a key-ring. Celluloid key-cards generally have a key-ring only.

The only essential tools used in removing and renewing the letters will be pliers and screwdriver (but a special tool —keying pliers—is available). To remove, insert the pliers so as to grip the key-lever underneath the key top; grip firmly and the pliers will then act as a fulcrum for the screwdriver, which should be placed on the top of the pliers near the extreme edge of the key-ring. Slightly raising the point of the screwdriver will remove the ring; the glass will usually fall out and the key-card be revealed. In some cases this can be cleaned up with an eraser. Where celluloid key-cards are used there is, of course, no need for the glass covering, but the method of removing remains more or less the same.

To renew the whole set of keys obtain a key-card sheet, on paper or celluloid as the case may be, place a key glass or key-ring over each letter in succession and mark round so as to show the exact size each letter must be cut to fit the key cup. Place each letter in position, see that it is straight, cover with the glass (if any), and then fit the ring, a little pressure with the pliers causing it to fit snugly; by placing a small coin over the ring so as to relieve the pressure of the pliers, the worker will avoid marking the ring and possibly breaking the glass or damaging the celluloid. A gentle pressure of the pliers is all that is necessary in most cases.

Glass and celluloid key-tops are liable to collect dust just inside the key-ring on the top of the glass or celluloid. By placing a small screwdriver inside a cloth and carefully working its edge inside the ring, dirt will be removed and the ring itself polished to some slight extent. A very little good metal polish may be used on the key-rings.

In the case of vulcanite key-tops, on which the letter is printed or painted, these are sure to become dirty in time, but they can generally be renovated by wiping over with a rag dipped in wood naphtha. Do not do this work near an open flame or fire as the naphtha is highly inflammable. Should a letter wear off entirely, a new key-top may have to be fitted, as although the latter could be painted on it is difficult to make it match the others. To remove a vulcanite key-top, heat an old pair of pliers in a smokeless flame, grip the key-lever immediately underneath the key-top, and let the pliers stay there for a few seconds only; the key-top can then be immediately lifted off. This little job requires care. If the pliers are too hot they may do damage, and if they get near the other keys they, too, may be loosened. It is well to press all the other keys out of the way so as to more easily get at the key required. For fitting the new key-top, heat the pliers as before, and with them grip lightly the extreme top of the key-lever in the actual place where the new key will go; merely make the lever warm, remove the pliers and immediately put the new key-top into its place, taking care to have it level and straight, as once the lever is cold again the key-top cannot be altered without removal and resetting. Should the whole keyboard be renewed, take care to leave, in each row, one old key right to the end, as this will be a guide to the proper height.

Instead of the heated pliers, a comparatively thin rod with a slot sufficiently wide to fit on the lever will answer the purpose, but the pliers are the cheapest and handiest.

It must be carefully noted that the foregoing method only applies to certain of those machines that have flat-metal key-levers. Some vulcanite key-tops have a small stem attached, which simply fits into a slot, and when pressed down to the desired height, will remain in position. To remove this kind of key-top, lift from the bottom of the stem (not the key-top) with the screwdriver, holding the pliers as a leverage, just as when removing the key-ring in other machines as previously described. In some other machines the key-top has a lug which is screwed to the side of the flat-metal key-lever.

The Rubber Feet.—The rubber feet on which most typewriters stand are rarely given a thought. That they re-

ceive extremely hard wear will be gathered from Figs. 5 and 6, the former showing the deformation and wear with age, and the latter a new foot. These two feet were of the same shape originally, and Fig. 5 is taken from an old foot chosen at haphazard. These rubber feet minimise the noise caused in working the machine by taking up or damping the vibration; they also prevent the desk being marked by the metal framework of the machine, and they raise the machine by a small amount from the top of the desk, which is an important point in those machines that contain parts working underneath which might be liable to catch on the felt pad used by most typists under their machines. Naturally the machine sinks into the felt pad slightly. Practical typewriter mechanics often discover that the key levers are catching in this felt pad quite unknown to the operator of the machine, and, of course, any catching or touching of the key-levers means a harder touch and wasted effort.

A typist can fit a new set of rubber feet in a very few minutes. On some machines the feet are screwed into position and on others they are pushed home into tapered sockets contained in the casting of the machine framework.

PAD MACHINES

Re-inking the Pads.—One well-known class of typewriters uses instead of a ribbon a felt pad which is thoroughly soaked in ink. Perhaps the best known and most universally used machine of this class is the Yōst. While it is not worth while to renew a typewriter ribbon owing to the fact that after its period of service it is generally too worn to serve again, it is quite possible and economical to renew a pad, and the necessary ink for the purpose can be obtained from most typewriter dealers. Both copying ink and non-copying ink may be obtained, as required. The ink is applied by means of a small brush and the pad does not need to be removed from the machine for the purpose. By pressing down some of the keys, the types are lifted from a part of the pad, and this is then inked with the brush. For pressing down all the keys at the same time, the keyboard is covered with a book or folded cloth or any similar article big enough to cover up all the keys; then a little depression will cause all the types to leave the pad and allow of the pad being inked all the way round.

Some late-model machines have a special lever (usually at the right-hand side of the machine) which pulls all the types away from the pad and automatically keeps them away as long as required.

One important point should be borne in mind. The ink must be allowed time to soak right into the pad before releasing the types to fall upon it, otherwise the types will get clogged up with ink and will need to be thoroughly cleaned before use.

Fig. 5

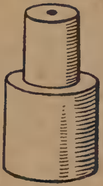


Fig. 6

Figs. 5 and 6.—Rubber Feet After and Before Long Use

To prevent the types falling back on the pad, a book or so may be added to whatever the keyboard has been covered with, or the type-bars may be tied with twine.

Renewing the Pad.—When the pad becomes worn by the constant falling of the types upon it, the holes formed in it are liable to hold the types down and to prevent their leaving the pad freely when the keys are depressed. Either a new pad is then required or the old pad may be reversed, but bear in mind that only the front and back of a pad are cf any use for inking the type, and that it is useless to present one of the sides of the pad to the types. Therefore, when turning or reversing the pad, simply bring the back part to the front and not one of the sides to the front.

In fitting a new pad, it is well to test this by gently pressing with a finger and

thumb, when the ink that oozes out at once shows which are the back and front and which are the sides. Very little ink indeed will ooze through the sides. Typists do not generally know that both the back and front of a pad can be used in the way here mentioned. Of course, if the pad is purchased complete with its ring there is no need to worry as to which is the front because this will have been determined already, but there is no need to purchase a ring every time a new pad is required.

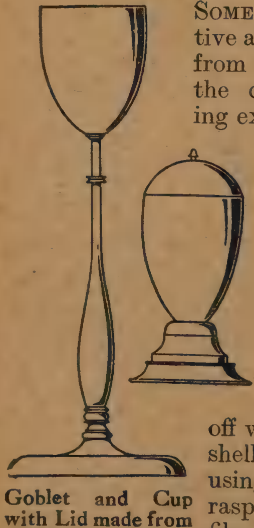
To remove the pad ring from the machine press down all the keys of the keyboard at one time in the manner already described, and when all the types are away from the pad the ring can be moved round; its join is at the back, and to separate this it will be necessary to move the pad until the join comes to the side, when it will be found that it is now out of the clips and can be easily lifted out.

To insert a pad, make the join come at the side and then move the pad round until the join goes to the back; in so doing the ring will slide into the clips that hold it in position. Then the types can be released to fall back on to the face of the pad. Be very careful to see that the join is in the correct position because, if it is not, a type might fall upon the join itself and that particular character could not then give a proper impression. So see that the type nearest to the join is quite clear of it.

It is rather important in re-inking pads to see that the same ink is used as was originally applied to the pad. Ink pads are messy things to handle, and the operator would do well to wear gloves.

Some machines are fitted with thin, flat pads which can be turned over and re-inked. They are easily got at and reversed.

Utilising Coconut Shells



Goblet and Cup with Lid made from Coconut Shell

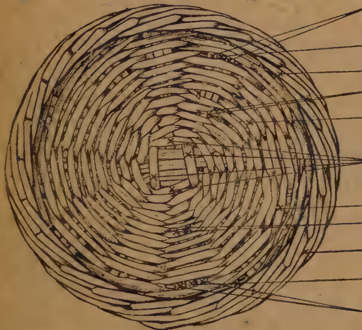
Some useful and decorative articles may be made from the outer shell of the coconut, which being extremely hard takes an excellent polish. The broad end of the nut should be cut off with a fine saw, and the interior removed with a knife. The husk of fibre on the outside of the shell should be scraped off with a knife and the shell then filed smooth, using first a coarse-cut rasp and next a smooth file. All file marks should then be carefully glasspapered out and the shell will be ready for polishing. The interior needs only a rub out with fine glasspaper.

An ornamental goblet, as here shown, may have a turned stem 10 in. high, and base of walnut about 5 in. in diameter. Tenons turned on each end of the stem are glued into holes bored in the base and nut.

The cup with lid, also shown, has a turned base or foot. The lid is the sawn-off portion of the nut, and is secured by a metal hinge, a small turned knob being glued by its tenon into the centre, as shown. The hinges are fixed with small rivets, for which holes must be drilled. A metal knob could be used, threaded at the lower end to take a nut. The lower part of the coconut is glued into a recess turned in the wooden base, but shaped feet tenoned into the shell would look more graceful than the turned base.

Basket and Wicker Work

Simple Basket Work.—Figs. 1 and 2 show a waste-paper basket that was made by Mr. Thomas Okey, in the course of a demonstration before the Society of Arts, to illustrate the chief strokes used in basket-making. It will be seen that the bye-stakes are merely inserted in the upsett, whereas the stakes are driven in at each side of the bottom sticks and pricked up to form the sides. Bye-stakes are only used in fitched work. Wicker furniture, generally, but more especially chair-work, is divided into two classes—stick work and fitched work. Fig. 3 is a fair example of a stick chair, and Fig. 4 of a fitched chair. In the stick chair the framework is made of stout willow sticks or cane, that part of it being put together with hammer and nails; the frame is afterwards lapped with plaited rush or raffia, and the filling-in is done with the same material. In the fitched chair there are only sticks to form the legs and arms (if any), and the corners of the back in a square chair, the rest being made of willows in much the same way as in ordinary basket work.



Figs. 1 and 2.—Waste-paper Basket, with Parts Named

The strokes chiefly used in basket work (see Figs. 1 and 2) are termed: a slew when two or more rods are woven in together; a rand when one single rod is woven at a time; a pair when two are woven alternately one over the other;

a fitch when two are woven alternately, one under the other; this last stroke is used for making skeleton work. A wale is three or more rods woven one after and over the other to form a binding or string course. Besides common borders, many other forms, such as plaited, roped, tracked borders, are used.

Materials.—Willows, also called osiers and rods, are divided into three classes after being cut—brown, white, and buff. for making wicker furniture, because of their beautiful natural colour and the splendid polish that can be given to them by putting on a coat of spirit varnish. Buffing, as it is called, takes place in the winter, the cutting of the willows sometimes beginning as early as October, after the leaf has fallen. At the buffing yard, the willows are sorted and tied up in bundles, and then placed in large open boilers, where they are kept boiling from

Fig. 3.—Chair in Stick Work

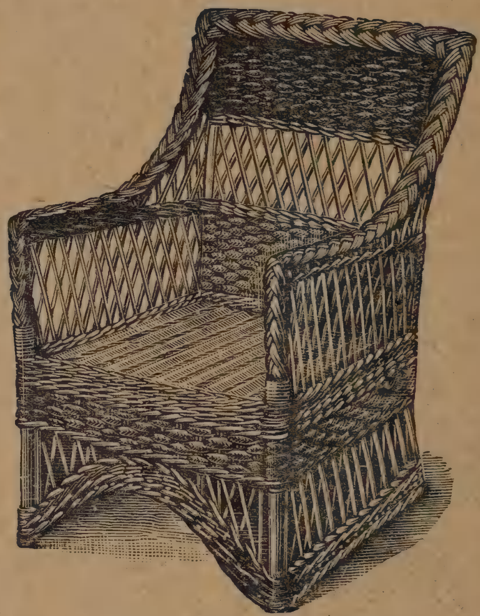


Fig. 4.—Chair in Fitched Work

Brown willows are the unpeeled rods cut in their green state and allowed to become dry and hard; before these can be worked they have to be made pliable by soaking in water for a week or even longer, or by boiling for a couple of hours. Brown willow is not used for indoor furniture, but it may be used for garden chairs, as the brown willow stands exposure to the weather better than either white or buff. White willows are obtained by peeling the green ones, these being cut in the early spring before the sap begins to rise.

Buff willows are the kind generally used six to eight hours. The colour is, of course the natural dye in the peel that is boiled into the willow, and deepens with age. Willows are generally cut at one year's growth, and are called one-year-olds; but some are left standing for another year, and are then called two-year-olds. The largest of these—that is, all $\frac{1}{2}$ in. or more in diameter at the butts—are called sticks; and all sticks, even if they be of three years' growth, are described as two-year-olds.

Willows are sold in large quantities, by weight and by bundles, sometimes called

bolts, and in small quantities by the pound. The prices vary according to the quality and size; the smaller they are the higher the price. In some places the bundles are named according to their length, as 3 ft., 4 ft., etc., up to 8 ft.; elsewhere they are mainly divided into four sizes, called small, long small, skein rods, and staking; while in other parts they are called tacks, hullens, middle, and large. Small quantities can be bought at nearly all the workshops where baskets or wicker articles are made. Good buff willows can be obtained at about 4d. per pound for tacks (fine small), $3\frac{1}{2}$d. per pound for hullens, and 3d. per pound for middle and large; while good buff sticks are about 2d. or $2\frac{1}{4}$d. per pound.

Tools.—The making of baskets and wicker furniture does not entail much expenditure in outfit. A great deal can be done with a very few tools, the work depending more on the skill of the hands and eyes than on anything else. The hammer may be any light kind with a long head. A pair of pincers, a yard measure stick, and a hand knife will also be required.

A shoemaker's knife, costing about $4\frac{1}{2}$d., will do very well for light work. A proper basketmaker's knife costs about 10d., but a gardener's pruning knife, if available, will be found better than either of the others.

Another necessary tool is the commander (Fig. 5), which is used for straightening bent sticks or bending sticks into the shape required. The best thing for the beginner to do is to have a beating iron made at the blacksmith's with a ring at the end, as shown by Fig. 6; it can then be used either for beating down the work, or for straightening or bending the sticks. It should be 11 in. long, $1\frac{3}{4}$ in. wide at the end, tapering to $1\frac{1}{4}$ in. near the ring, and $\frac{3}{8}$ in. thick at the back, and a little over $\frac{1}{8}$ in. at the front, the hole in the ring being a full inch in diameter.

A pair of shears (Fig. 7) for cutting the sticks will cost from 4s. to 6s.; but a very useful substitute may be had by getting a pair of gardener's spring pruning shears, costing about 1s. 6d. These are very handy for light work, while for heavy sticks a saw can be used.

Two bodkins will be wanted—a 4-in. and a 6-in. A picking-knife (Fig. 8), about $6\frac{3}{4}$ in. long, is so much better than an ordinary knife for taking off the ends from the finished work that it would be advisable to get one.

Other tools are a cleaver, for splitting the willows into three or four parts; a shave, for taking off the inside of the splits, thus making them into skeins; an upright for making the skeins of a uniform

Fig. 5.—Commander

Fig. 6.—Beating Iron and Commander

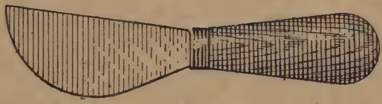


Fig. 8.—Picking Knife

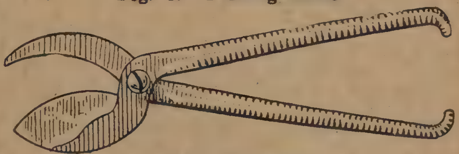


Fig. 7.—Shears

width; and a screw-block for making bottoms, square seats, etc.

Oval Baskets.—As an example of oval basket work, the making of a linen basket will be described. The bottom is begun under the workman's feet by tying a slath. Eight rods are used in properly tying both small and large slaths, which differ only in length and thickness. The slath is generally laid about half the length of the finished bottom, that is, from opposite points of the two tie-rods first bent round. In bottoms up to 14 in., three lays of bottom sticks are used; for larger sizes four are required, also thicker sticks. For a 14-in. bottom, cut seven sticks about

12 in. long; shave a little off along their middle and cut a piece of rod 8 in. long to divide the eight tie-rods. This 8-in. piece is required only in the three-lay slath.

Lay the sticks and the eight tie-rods on the board within reach; take four of the rods and place the butt ends under the right foot, quite level (see Fig. 9). At about 5 in. from the extreme ends pick up A and C; put two of the sticks in between these two and between B and D; drop A and C, and pick up B and D; place in between B and D and A and C three sticks about $2\frac{3}{4}$ in. from the first two; drop B and D, again picking up A and C, and placing in the last two sticks so that the three lays may be in a 7-in. space. Now take the 8-in. piece, and place it so that it may lie under the three middle sticks, its ends resting on top of the two outside lays of sticks, where they are finally cut off neatly, as shown at H (Fig. 9).

The other four rods are now worked, one at a time, between the sticks E, F, G, their butts the opposite way to the first four, as shown at I J K L (Fig. 10). Tap the rods as close together as possible by using the iron between the sticks. Keep the feet firmly on the right-hand end and side commenced at; pick up D, pass it very tightly over I J K L, then under the two sticks G, over F, under E; leave each projecting as shown. Now pull up I by the side of J, also K between J and L; whilst holding I and K, pass C under I J K L, over G, under F, and over E. B and A are worked just like D and C. Do not forget to pull up the sticks a little every time a rod passes under them; the object of this is to give a crown to the bottom (see Fig. 11). All the tie-rods will now be projecting at one end of the slath; turn it round and hammer A B C D close. Then work I J K L round that end exactly as the opposite end was done. By pulling the four butts to the left whilst working round them, they are got in line as nearly as possible. Before opening the sticks, D C and I J must be worked in the same manner as the first two at each end. After that, the tops of the tie-rods are worked round in pairs and in between those sticks that require to be opened. Perhaps the end sticks will be the best to start at. There four, say A B C D, must be divided into three separate portions to receive the pairing and finally the stakes; pull D to the left, work in A and B between D and C, push A to the right, again working the tops of A and B between the butts A and B; the butts C and D are not divided at either end. Open the sticks E, leaving sticks F undivided. Now serve I J K L exactly the same way; with L K open G, then open E with I and J, then work round to the other tops, when C and D will have to be worked again by opening the sticks G on that side of the slath. Now the required number of sticks is opened; the tops are simply paired under and over each other between the sticks, and are so finished up.

When the tops of the last pair of tie-rods have been worked up, a good handful of rods will have to be pointed at their butt ends, the points being cut the reverse side to those of the stakes. Then draw them in their different lengths, using the thinnest and shortest first, one pair at a time.

There are several ways of filling up, but the following is as neat and as close as any: Wet all the points of the first length, take a pair, and with the left foot on the slath push in the pointed rods at the left-hand side of the first two sticks that formed the lays—that is, E (Fig. 11) on one side of the slath, and G on the other; the foot holds the slath firmly on the opposite side to that on which the pairing rods are pushed in. Now bend down first one rod in front of the stick, behind the next, and in front of the three of the middle lay; leave it there whilst the second rod is served the same, and so work them up under and over each other. Start the next pair at the left side of F and E or G (whichever it may be), and so continue at either side until the bottom is 14 in. lengthways. When a slath is laid half the length of the finished bottom, the workman does not trouble to measure for width; it will be proportionate in all sizes. By laying the slath shorter or longer there is easily obtained a bottom

wider or narrower as required for special purposes.

Finish off the bottom by pushing the ends of the last pair in and out of the pairing, pick off the ends neatly, and with the shears cut off the ends of the sticks whilst they are held under the foot.

Fig. 12 illustrates the method of opening the bottom sticks, the letter references agreeing with those in Fig. 11.

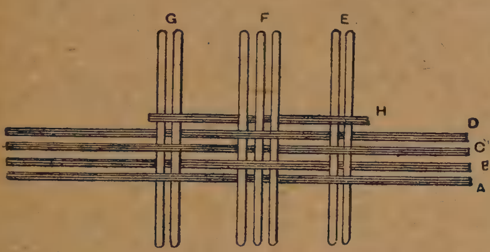


Fig. 9.—Slath for Oval Linen Basket

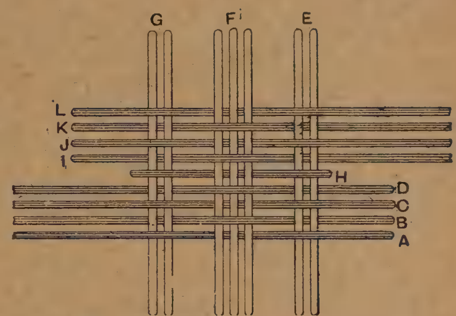


Fig. 10.—Slath Rods in Position

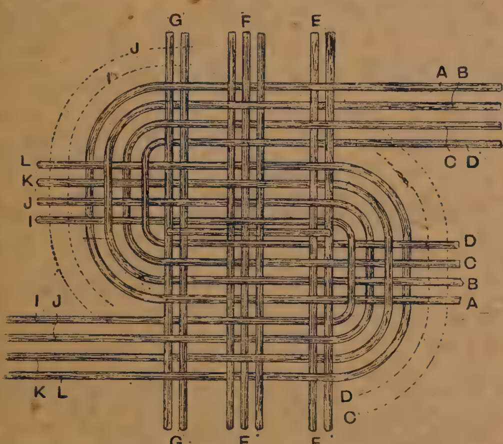


Fig. 11.—Tying the Slath

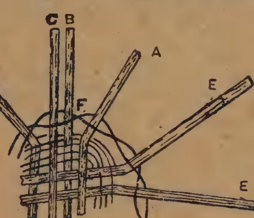


Fig. 12.—Re-opening Bottom Sticks

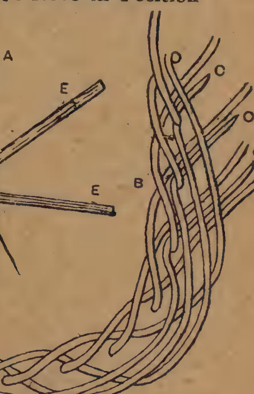


Fig. 14.—Bordering

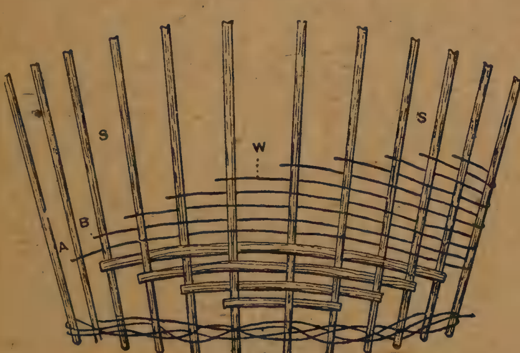
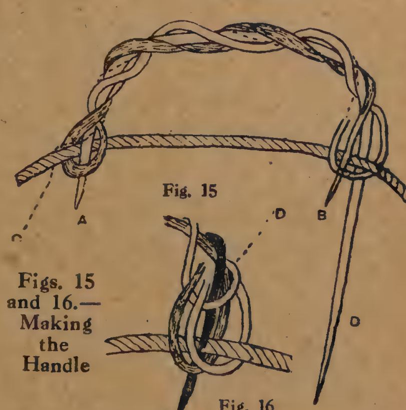


Fig. 13.—Sliding Up



Figs. 15 and 16.—Making the Handle

Stakes for the bottom can now be cut. Sixteen pairs are required for a randed basket; for a slewed basket manage to have an odd one, say fifteen and a half pairs, putting the odd one where two of the sticks happen to be closer together. Wet the points of the stakes, stand with one foot on the bottom, and push in the stakes—a pair to each stick—at either side of the stick. Of course, the three middle sticks in each of the sides and the pair at each end are reckoned only as single sticks. After all the stakes are in, turn all completely over, and gently force the bottom down on the board; put the right foot lightly on the bottom, and prick up each stake in turn; afterwards place them in a large hood. Now sit on the board and drive in the stakes closely by using the iron on their bends.

Begin upsetting with the top ends of four rods at the left-hand shoulder of either side (as the bottom lies before the worker) by pushing in the cut top ends at the side of four stakes. Work the rods in front of three stakes and behind and out of the fourth or unoccupied stake. If the rods are short, they will have to be left unfinished at the curve on the other side of the bottom, while four more rods are pushed in exactly as at the first side and worked round to the first tops, when one is dropped and three are worked on the first four, outside two stakes and inside one. If the first four rods are sufficiently long to go right round the bottom and lap over their own tops, that will be found most convenient. The butts of the two sets, or the one set, whichever is used, must be pieced with three other rods at the sides and worked up.

Another round of upsetting can be worked on top of this, if preferred; it is always advisable to have a good foundation of upsetting on any basket. Cut off any butts protruding, and then prepare the randing by drawing some small rods into their different lengths. Pull the stakes at both ends of the bottom out of the hoop, only leaving in a few at either side, as these baskets require a good spring of 8 in. at the top from end to end. Weave in a few short pieces at both sides first to raise the latter a trifle; work these in as shown in Fig. 13, in which figure it will be noticed that the butts as well as the tops are left projecting outside the basket as the inside requires to be as smooth as possible. After working four or five short pieces at both sides, start the randing by placing the first rod as shown at A (Fig. 13), and work it up; swing the work back and place in B, and so on, working round to the right until the proper height is reached, namely, 7 in. at the ends, when the measurement should be 22 in. across from end to end. Raise the sides about $2\frac{1}{2}$ in. higher than the ends by working a few rods along each side until they are of equal depth, when a wale of three or four rods, as preferred, can be worked round, starting at one side, and piecing the butts at the opposite side, working them up. If three wale rods are used, work each alternately inside two stakes and outside one; if four are used, inside two and outside two is the method, and, of course, this gives a better finish both inside and outside the basket. The four wale rods that are pieced with are worked right up, overlapping the tops of the commencing four.

The border is begun at the left hand (A, Fig. 14) by laying down five rods, and working each in front of four stakes and behind two. The first three stakes finished are seen at C. When the border has been finished by cramming, the butts and tops can be carefully trimmed off with the picking knife, holding the basket sideways between the knees.

Two handles are put on, one at each end; for these, cut four rods, press in the basket with one foot, and push in two of the rods from the top of the border beside a stake and about three or four stakes apart, or wide enough to allow of the hand passing between them. Bend the left-hand rod A (Fig. 15), and pass its top under the border from the outside at the right-hand side of the second rod B, and pull it inside the basket, just leaving sufficient outside to form a bow, on which the other rod and its own top are lapped. Twist the second rod rope fashion, lap it over the bow three times, push its end

under the border (outside), pull it through, again lapping it over the bow three times, and then under the border at the right-hand side; pull it through, lap it over for the third time, and leave it outside the border hanging down. Next twist the bow rod top first pulled through, and lap it round the bow by the side of the second rod; it is worked three times across the bow (three laps each time, of course), and then it is pushed in between the two rods and its own butt, where they go through the border (outside); both the tops are pulled tightly down and cut off close. Fig. 15 explains the method of working the handle, and Fig. 16 shows how the rod D (Fig. 15) is turned back at the second turn across the bow.

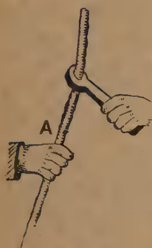


Fig. 18.—Straightening a Stick

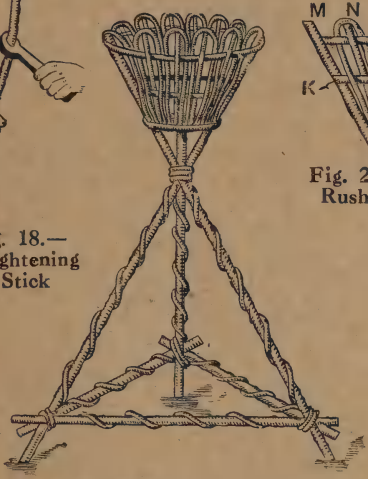


Fig. 17.—Flower-pot Stand

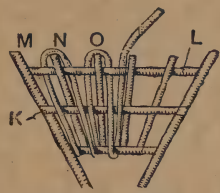


Fig. 25.—Fixing Rush on Bowl


Fig. 19.—Cross-bar Nailed to Leg

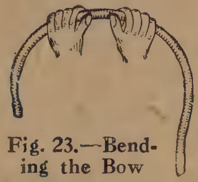


Fig. 23.—Bending the Bow

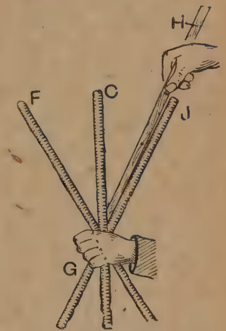


Fig. 21.—Measuring for Depth of Crossing

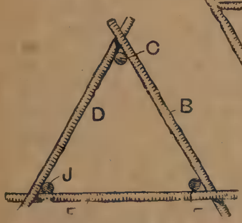


Fig. 20.—Legs Nailed to Bars

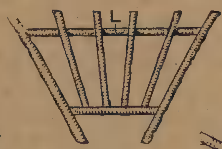


Fig. 24.—Rails Nailed On

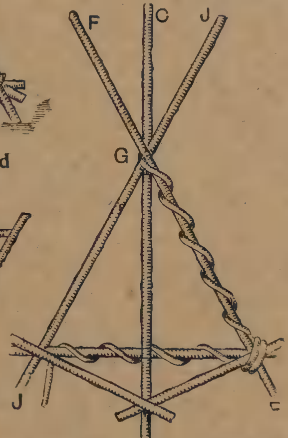


Fig. 22.—Lapping Rush Round Legs

Flower-pot Stand.—To make the rustic flower-pot stand (Fig. 17), three long buff two-year-old sticks about $\frac{5}{8}$ in. thick at the butt end, some rush plait, a round wood bottom, a few fine wire nails, and a cane about 3 ft. 6 in. long and from $\frac{3}{8}$ in. to $\frac{1}{2}$ in. thick will be required. The round bottom, $4\frac{1}{2}$ in. in diameter, can be easily made from a piece of $\frac{1}{2}$-in. board.

For working, a sitting board 3 ft. 6 in. long, 1 ft. 10 in. wide, with cross-pieces underneath $1\frac{1}{2}$ in. thick, is generally used, but this can be dispensed with if the work-room has a boarded floor. In this case a workboard the same length as the sitting board, but for furniture work about 2 ft. 6 in. wide, and a strong box about 1 ft. 6 in. long, 9 in. deep, and 7 in. wide, can be used. Laying the box on its side, turning it upside down, or standing it on end, enables the worker to sit at different heights according to the work in hand.

Take one of the sticks, and cut off 2 in. or 3 in. of the butt end (thick end) with the shears or a small saw. This is done because willow sticks will usually be found to be split for 1 in. or 2 in. up the butt. To cut a large stick with the shears, take hold of the butt end with the left hand,

then, kneeling on the right knee, and with the shears in the right hand, put the blade underneath the stick at the place where it is to be cut, press down the top handle, and at the same time gently pull the butt upwards with the left hand; a clean cut should be the result. Next cut a length of 2 ft. 9 in. and a length of 1 ft. 3 in.; also, if there is sufficient left, four pieces 8 in. long. Divide the two other sticks into the same number of pieces, and there will be three legs 2 ft. 9 in., three cross-bars 1 ft. 3 in., and twelve short rails for the bowl of the stand. If they are not quite straight, they must be straightened with the iron or commander. To do this, hold the stick in the left hand, with the bent part A (Fig. 18) pointing away, slip over it the ring of the iron, and by pressing down the end of the iron with the right hand, force the stick into shape. Do this very gently, and commence a little above the bend. At each time of pressing, let the ring of the iron slip a little farther down, or the stick may be broken. If the sticks are very dry, soak them for half an hour before straightening.

Next make a mark on the three legs 4 in. up at the thick end, and lay one flat on the workboard. Then nail one of the cross-bars across at the height marked, letting it project over the leg $1\frac{1}{2}$ in. (see Fig. 19), the main portion being on the left-hand side of the leg. Clinch the nails, which should be $1\frac{1}{2}$-in. fine wire. Then do the same to the two other legs, making them the same length. Then nail all together as shown in Fig. 20. To do this, nail the bar of B into leg C, and, letting the bar D rest on the workboard, nail the bar E to the leg F. Repeat at the other corner, letting the loose end of the bar come underneath the end of the cross-bar, which should be first fastened to the leg. The best way to do this is to sit flat on the board, and use the legs for holding the sticks firm. Now take hold of the three legs with the left hand as shown at G (Fig. 21), letting them fall one round the other. Then in the right hand take the yard stick H (a willow with the inches cut in makes a good one), place the end in the hollow formed by the crossing of the sticks, and measure 1 ft. 1 in. to the top of each leg, gently pushing up or down as may be required. Then, holding very firmly, put a nail through J into F (Fig. 21), and through C into J, and then through F to C.

Before making the top or bowl of the stand, it is as well to lap the legs and cross-bars. To do this, start by nailing the rush to the leg F (Fig. 22), just where the legs cross one another. Take a running lap down the leg six times in all, then take two turns round the leg and ends of the cross-bars together. Then along the cross-bar from F to J, doing that in four laps, twice round the ends of the bars and leg, and then up the leg J. On reaching the junction of the legs G, go three times round them all, then come down leg C. On reaching the cross-bars, nail the rush to the leg underneath, so that the end will be under the two laps that have yet to be placed on. Next push the end of the rush under that already on the leg J, fasten with two small nails ($\frac{3}{4}$-in. fine wire should be used), lap along the bar to the leg C and two laps round the corner. Then to F, finish off underneath the leg, and the bottom part of the stand is finished.

Now make the bow for the top of the legs. It may be made with a willow two years old, after soaking for about four hours, but a piece of cane is recommended for a beginner. Grasp it with both hands, the thumbs extended and nearly meeting (see Fig. 23). Bend round into shape, thumbing it all round, and cut a long slipe (the trade term for a long slanting cut) at each end, inside at one end and outside at the other. Then nail together over the iron placed on the knees with $\frac{3}{4}$-in. nails, to make a bow or hoop $10\frac{1}{4}$ in. in diameter. Next make a mark 1 in. from the top of each leg stick (inside) and nail the bow just below the mark, seeing that each leg stick is the same distance apart round the bow. Then place the wood bottom inside the legs and fasten 6 in. down below the bow, by putting a nail through each leg.

The 8-in. rails can now be attached. Put four between each leg at equal dis-

tances apart with the tops standing 1 in. above the bow (see Fig. 24). First nail into the wood bottom, using 1-in. nails, turn the stand so that the legs are away from the worker, place the beating iron on the knees, and nail the rails to the bow. Next nail the end of a piece of rush, long enough to go twice round the bowl on the outside, to one of the leg sticks $1\frac{3}{4}$ in. from the bow K (Fig. 25). Take it right round at the same height, tacking it on every other stick. Then go round again below the first round, pushing the ends under so as not to be seen from the outside.

Lay the stand across the knees, with the bowl to the right-hand side, take a long piece of rush, push the end from the inside of the bowl under the bowl L (Fig. 25), outside the two rounds of rush K, and nail to the wood bottom between parts M and N. Then pull fairly tight, and carry over the top and outside edge of the rail N, push down under the bow and outside of the rush K, nail between the rails N and O, and repeat the process all round. The rush need not be pulled right through, but only far enough to nail into the bottom. Fasten to the tops of the rails with a 1-in. nail. Then nail a piece of rush round the rails where they fasten into the bottom. This will cover the ends of the rush and give a better finish. Trim off all loose ends, wash, and when thoroughly dry, give a coat of brown hard spirit varnish. A cheaper stand is made by using lighter sticks, making the bow only $8\frac{1}{2}$ in. in diameter, and putting three rails instead of four between the legs. Very common ones are made with only two rails between, and the legs 3 in. shorter.

If the buff sticks cannot be obtained, white ones dyed by dissolving a little bismarck brown in hot water and pouring it over them make a good substitute.

Cleaning Wallpaper

BREAD is commonly used for cleaning wallpaper but bran or fine sawdust is even better. A dry flat sponge will also be needed for rubbing it into the paper. Make sure that there are no hard, gritty places on the sponge, and see also that the bran or sawdust is free from sharp pieces. It is not a bad plan, especially with sawdust, to pass it through a fine sieve, and in this way get rid of any small chips of wood. Spread a dust-cloth on the floor just below the part of the paper which is to be treated. First of all dust the surface of the paper very lightly with a feather brush to remove all the larger pieces of dirt. Then spread some of the bran or sawdust on to the sponge, and rub the paper briskly. Renew the treatment if necessary.

The bran or sawdust should not be used twice over, seeing that if it is dirty it is likely to smear the paper.

This method will clear away all ordinary dirt from wall coverings, but it has no effect on grease spots. These must be treated separately. Where these are not very bad, or have been recently formed, the following simple method is almost always a success. Fold over several thicknesses of brown paper, like a pad. Then place these against the grease spot, and hold a hot flat-iron on the top. One or two applications should draw the grease right away from the wall covering into the brown paper. With a very deep-seated grease spot the above method may not be completely successful; even if some of the marks disappear there may still be an ugly patch left behind. Sometimes if the spot is dabbed with pure benzine or with petrol (both of them dangerous to use close to a light), the spot will finally vanish, but a better way is the following: Mix some fuller's earth or pipe-clay into a paste with a little water. Then carefully plaster this over the grease spot, and allow the material to remain until it is quite dry. At the end of this time the stuff may be removed, when it will be found that the grease has been absorbed.

Making and Using Hektographs

HEKTOGRAPHS or jellygraphs afford a convenient means of duplicating written matter. They are of two main kinds, the gelatine and the "putty."

The Gelatine Hektograph.—To make a gelatine copying pad, soak in cold water 2 oz. of pale gelatine glue until it has the appearance of a thick jelly; then place it in a piece of fine muslin, and squeeze away any surplus water that has not been taken up by the glue. This should be put in a thick earthenware vessel with 10 oz. of glycerine, and should then be placed in an oven and simmered with a gentle heat, stirring at intervals to prevent burning to the bottom of the vessel. After thorough mixing, add 10 drops of oil of cloves, which will prevent the preparation turning mouldy. The mixture should next be poured into a shallow tray 12 in. square, with sides 1 in. high, and stood in a cool, level place so that the surface of the pad will set evenly and entirely free from blisters. It generally sets in about four hours, when it is ready for receiving the copying matter (which must be written with a special ink). Before using, rub the surface of the pad with a damp sponge, then place the written matter gently on the pad face downwards. The paper should be gently rubbed, and allowed to remain for a few minutes. On removing the paper there will be found on the pad a perfect impression of the written matter. By simply placing a blank sheet of paper on the pad and lightly drawing the hand over the back, there will be found an exact facsimile of the original copy. When sufficient impressions have been taken from the pad, the surface should be washed with a sponge until most of the ink has disappeared. The pad should then be remelted over a slow fire or oven, and if the mixture assumes a blue colour a little whiting, which takes up the ink stains, may be added.

Another recipe for hektograph composition is: Take 160 parts of gelatine, 250 parts of water, 600 parts of glycerine, and 250 parts of white sugar; heat and mix as already described.

Non-glycerine Hektograph.—It is possible to do away with the most expensive of the usual ingredients, the glycerine. A good recipe is: Leaf gelatine, 1 part by weight; water, 5 parts by measure; golden syrup, 8 parts by measure; carbolic acid (10 per cent. solution), $\frac{1}{16}$ part by measure. Break the leaf gelatine into small pieces, soak in the water for about thirty minutes, heat in a water-bath until dissolved, add the golden syrup and acid preservative, filter through fabric into a shallow dish, and skim any scum with the edge of a clean piece of paper. For a 10-in. by 8-in. dish about $2\frac{1}{4}$ oz. of the gelatine, and other ingredients in proportion, will be about right.

Another Kind of Hektograph.—There is on the market a successful hektograph copier known as the "Plex." The following recipe is not actually for the "Plex"

composition, but for something resembling it: Best gelatine or glue 1 part is soaked overnight in cold water and the excess of water poured off. The glue is then warmed on a water-bath with the addition of 10 parts of glycerine, to which may be added 4 to 6 parts of finely powdered heavy spar and 1 part of dextrin, the whole being thoroughly mixed, with constant stirring. This molten mixture is poured into a shallow metal pan or box of tin or zinc and allowed to cool, when it should possess the tough, elastic consistency of a printer's roller. The letter or sketch to be duplicated is then written or traced on a sheet of heavy paper with an aniline ink. When this is dry, it is laid inked side downwards on the gelatine plate and subjected to moderate and uniform pressure for a few minutes. It may then be removed, when a copy of the original will be found on the gelatine, which will have absorbed a large amount of the ink. The blank sheets to receive the copies are now laid one by one on the gelatine plate, subjected to moderate pressure over the whole surface with a wooden or rubber roller, or with the hand, and evenly stripped off by inserting the nail under one of the corners. If this is done too quickly or roughly the composition may be torn. From 40 to 60 legible copies may be produced in this manner. When the operation is finished the plate should be sponged gently with water and the ink remaining on the surface of the gelatine soaked out. The superfluous moisture is then carefully wiped off, when the plate is ready for further use.

The "Putty" Hektograph.—A simple mixture of glycerine and very finely-ground whiting extremely well kneaded has been recommended; but in the course of considerable experience by different people the results obtained have been so uneven (due, possibly, to variations in the purity of both of the materials and the fineness of the whiting) that readers are not advised to spend much time upon it, success being so uncertain.

Hektograph Inks.—The following is typical of published recipes for hektograph ink: Take ¼ oz. of aniline black (soluble in water), 2 oz. of methylated spirit, 2 oz. of water, and 4 oz. of glycerine, and warm until the colour is properly dissolved. Coloured inks may be made with the ingredients mentioned, simply by varying the colours. For red ink eosin should be used, and for green ink methyl green. The trouble about such inks is that they dry far too slowly, due to the presence of glycerine. This compound is somewhat hygroscopic, and ink containing it would only dry moderately rapidly on papers which were unglazed and absorbent. True hektograph inks consist of alcohol-water solutions of various coloured aniline dyes, and are sometimes thickened up by the addition of suitable quantities of gum arabic. The following recipes for hektograph inks are said to be very efficient: (1) One part of methyl violet is dissolved in 1 part of methylated spirit and 8 parts water, and the solution used in the ordinary way. (2) Five parts of methyl violet are dissolved in 5 parts of alcohol and 35 parts of water in which 5 parts of gum arabic have previously been dissolved. Other suitable aniline dyes could, of course, be used in place of methyl violet. (3) The following are improved glycerine inks: Dissolve 1 part of methyl violet in 8 parts of water, and add 1 part of glycerine. Gently warm the solution for one hour, and when cool add ¼ part of alcohol; or take methyl violet 1 part, water 7 parts, and glycerine 2 parts.

Using Copying-pencils instead of Ink.—According to Mr. J. W. Purvis, copying-pencils are effective, but only applicable to hektograph flexible gelatined copying sheets (sheets of absorbent paper immersed in molten hektograph composition once or twice and allowed to dry). Many pencils have been tried with varying success, and Mr. Purvis recommends the "Eagle Manifold," which renders fifty legible copies. A rough paper for the original is necessary. Better, he says, is a non-absorbent material such as acid-etched ground-glass. Care must be taken to secure good contact all over the surface of the jelly. The ground-glass should be left in contact for fifteen minutes or more.

Hearth and Wall Tiling

Laying Tiled Hearth.—Hearth tiling is the simplest form of tiler's work. In new buildings, where there are many hearths to lay and stones to fix, it is better to lay the hearths before fixing the stoves. The hearth is often enclosed with an oak border, 2 in. by $\frac{3}{8}$ in., which is glued and rebated to floorboards, as at A (Fig. 1). The custom of fixing and finishing this border before the size of the tiles can be ascertained must often lead to unsatisfactory results. The 3-in. tile as supplied by different makers shows considerable variation in size, and should the tiles run small, some $2\frac{15}{16}$ in. for a 4-ft. by 1-ft. hearth, filling out to the border with neat cement, as shown at B (Fig. 1), would be necessary. Again, should the tiles be a trifle large, say $3\frac{1}{32}$ in. in a hearth of the above-given dimensions, cutting must be resorted to. The writer has seen finished hearths in which all the cutting had been done at one end, instead of working from the centre, the result being very unsightly. The effect is decidedly unpleasing when the lines of a stove show a much larger piece of tile on one side than on the other. It is much better to leave the borders until the tiles are delivered. The tiles can then be laid out as shown by

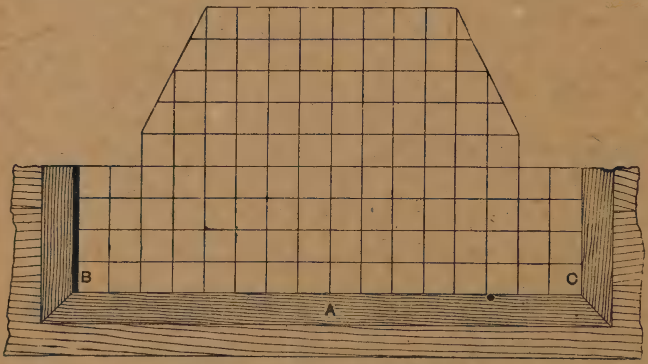


Fig. 1.—Plan of Tiled Hearth

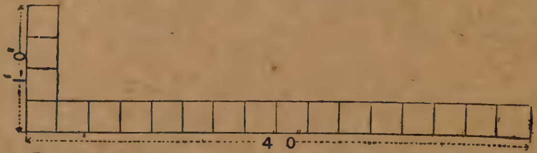


Fig. 3.—Measuring Tiles for Fixing Border

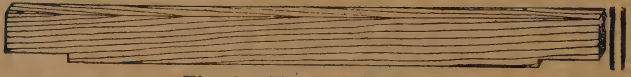


Fig. 2.—Traversing Rule

Fig. 3, and the internal measurements for the border taken from them.

The tiles should be bedded in neat portland cement. When this material is quick-setting, it is customary to kill it by disturbing the initial "set," and re-mixing with water into a plastic condition. This operation greatly retards the setting, and thus gives more time for the execution of the work. The floating of the cement bed to receive the tiles must be done with care in order to secure a perfectly plane surface. Fig. 2 shows a traversing rule with the extreme ends cut away to a trifle less than the thickness of the tile. The cement should not be very wet, but of such consistency that it can be spread out fairly level with the trowel. The borders being used as a screed, and the rule worked from side to side, the bed can be laid with accuracy. The bed for the back hearth can be worked off the front; and this method, though it may appear to be rather troublesome and expensive, is justified by the results. The method of measuring the tiles for the fixing of the border is shown by Fig. 3.

The tiles should be thoroughly soaked in water, and allowed to drain before use. The laying can be begun by putting the tiles lightly into position, working from the centre so that any cutting necessary may be done at the borders. In no circumstances should the tiles in the centre be cut. Indeed, where, as in the more expensive patterns, there is a centre-piece, cutting is impossible, as the fixed piece must be laid exactly central. The cutting is done with a hammer and a small chisel, the glazed portion being first carefully cut through. Any rough edges can be partly chiselled off, and, to make a snug fit, can be rubbed on a piece of stone with sand and water. Only sufficient tiles should be laid (see Fig. 1) to support the stove; the remaining part of the back hearth may be filed out with compo or the tiles can be filleted round to keep them in position.

A piece of planed wood with the edges rounded off on one side, as shown in Fig. 4, should now be used for beating the tiles firmly to the bed, and to place them in a horizontal plane by rubbing them with a gyratory motion. The beating and rubbing have the effect of bringing to the surface any superfluous water, most of which can be wiped off with a cloth, while a little dry cement sprinkled over them, and worked over the surface with a piece of old rag, will quickly absorb the rest, and fill up any joints which may happen to be a trifle large. The tiles can now be cleaned off and the joints raked

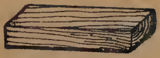


Fig. 4.—Wood Pat

Figs. 5 and 6.—Wrong and Right Methods of Jointing Tiles

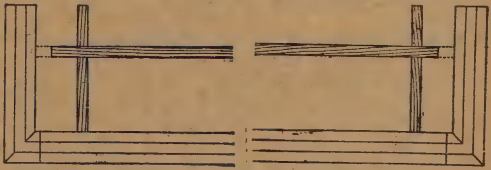


Fig. 7.—Method of Screeding Bed with Curb Fixed

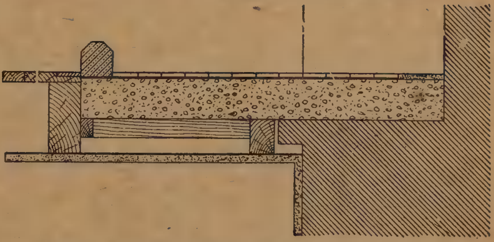


Fig. 8.—Fixing Marble Curb to Concrete

out. Sometimes this latter operation is left undone, with the result that, as shown in Fig. 5 (where the cement fills up the bevels), large and unsightly joints are made where small and neat ones should be visible. A small or defective tile can now be readily seen, and can be easily taken up with the blade of an old knife; or any irregularity in the joints can be attended to.

The advantages gained by laying the hearth first are many. Foremost among them is superior finish; and the stove has a level bed to stand on, instead of being packed up on several pieces of slate, an operation that is not performed without

difficulty. In laying the hearth last, these pieces of packing have to be drawn out, and tiles placed under. If the stove drops a little, another difficulty presents itself, some of the results being that the economiser is useless because it does not fit, that cutting becomes necessary, and that the tiles in juxtaposition to the stove are not level. The increased ease with which the stove can be fixed reduces, of course, the amount of movement upon the tiles, and by laying an old drop-sheet or pieces of board across the hearth, all scratching can be avoided, thus overcoming the chief objection to laying the hearth first.

The Curb. — It has become quite common to enclose the hearth tiles with a marble curb. Where the fender is fixed a little below the floor-line a slight difference is necessary in the method of screeding. Instead of making use of the floor, two pieces of wood are bedded level to the required height, and cement is filled in between and finished off with a straightedge or traversing rule (see Fig. 7). The screeds can then be taken up, and their position filled in with cement. The bedding of the curb to floorboards is objectionable, as the slightest vibration breaks the joints and in a short time reconstruction becomes necessary. In laying a tiled hearth in an old building, it would be very expensive to reconstruct entirely the trimming joist to the first place. The difficulty may be met by having the curb in one piece. In new buildings, when it is known that curbs are to be fixed, the trimming could be kept back sufficiently for the bedding of the curb to concrete, etc. (see Fig. 8). The curb should be squared from the mantelpiece and bedded in the cement, the joints being made in plaster, with the addition, if required, of a little colouring to match.

Fig. 9.—Common Arrangement of Wall Tiling

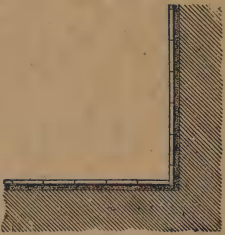


Fig. 12

Fig. 13

Figs. 12 and 13. — Two Methods of Bonding Internal Angle

Fig. 10

Fig. 11

Figs. 10 and 11. —Two Methods of "Breaking" the Joints

Wall Tiling.—For all kinds of wall tiling the preparation of the surface to be covered is a detail that will well repay careful attention. When the tiles are to be fixed on brick walls, the joints must be raked out and the wall well brushed in order to form a good key for the cement rendering, which should be about $\frac{1}{2}$ in. thick, and composed of 1 part clean sharp sand to 1 part portland cement. The rendering, when finished with the floating

rule, should be left rough to make a good key for the bed of the tiles, and this is best accomplished by brushing over the surface with a stiff broom when the water has gone off. It is also advisable that the wall should not be floated many days before fixing the tiles, as the bed will combine much better with the rendering if the latter is not thoroughly set.

For the more elaborate patterns of wall tiling a large-scale working plan would have to be prepared ; but assuming that the tiler is left to his own resources, let him begin by taking the height and width in order to ascertain the best method of filling in. If the width of surface allows of the tiles filling in without the use of halves, he would fix the tiles with their vertical joints carrying an unbroken line from floor to ceiling, as shown in Fig. 9. If half-bond is required the use of half tiles is resorted to, and each alternate course is started at the extreme ends with one, as shown in Fig. 10. Again, should the surface fill out to a half-tile, or a little under, the alternate courses would be commenced with a half-tile at one end and finished with a whole tile in the same course at the other end (see Fig. 11).

When the tiling is continued to another wall, so that an internal angle is formed, the work is bonded in as shown in Figs. 12 and 13, and this must be allowed for in setting out, and a corresponding deduction made in filling out the tiles. The height between floor and ceiling should next be taken, and the work set out for any cutting that may be necessary in consequence of the irregularity of the floor-line, the cut tiles being placed in the first course, where they will be least observed. It is also necessary to test the ceiling line with respect to the finish of the tiles ; and should this line be found a trifle out of level, the work can at times be eased a little to avoid cutting. The operator working downwards, the filling is taken to the lowest part, and, by gauging up the size of tile from the floor, all cutting can be done in one course, unless the floor surface is at an exceptional inclination.

Before the fixing is begun screeds should be fastened to the wall and the tiles sorted over, as they will be found to show slight variations in size. The sorting is best done by holding one tile upright with the left hand on a level surface and placing the tiles one by one against it,

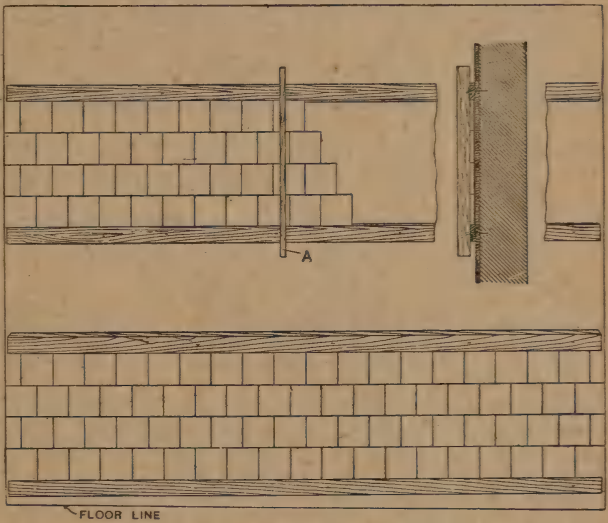


Fig. 14.—Height of Tiling Set Out in Bays

when differences are easily detected. If those that are of nearly uniform size are kept together, the horizontal and vertical lines will be much better kept than they would be if the tiles were fixed without sorting. The number of courses that the small and large tiles respectively will fill should be noted, as the screeds must be fixed to the wall at such distances as the tiles will fill out accurately. Wrought batten is generally used for the screeds, the thickness being equal to the tile plus the bed ; and they should be fastened to the walls with nails of sufficient length to obtain a firm fixing, while allowing enough to protrude from the screed to admit of drawing with pincers. If

this method is adopted, the nails can be withdrawn and the screeds struck without flushing or detaching any of the tiles. Both these accidents are common when the screeds are removed by prising with a chisel. The first screed is fixed at the level line, and another fixed according to the dimensions of the tiles, at a height of, say, 2 ft. 6 in. above it, and so on until the height is set out in bays as shown in Fig. 14. The screeds should be kept perfectly level, and plumb from top to bottom, for on their fixing will depend the expedition and neatness with which the work will finish.

The tiles are thoroughly soaked in clean water and allowed to drain. They are bedded in neat cement. The fixing can be begun at the bottom, filling in between screeds; and by the use of a small straightedge, as shown at A (Fig. 14), the work can be kept plumb and the courses finished level. In beginning each bay great care should be taken to set out the bond correctly, for any mistakes are irreparable without undoing the work.

It is advisable to regulate the work so that the screeds can be removed on the following day, when the bays can be filled in and the work completed, all damaged tiles being reserved for the cut course at the base of the wall. With walls of small dimensions, it is usual to cut the first course in level, and keep fixing upwards without using screeds. In these circumstances, the tiles are plumbed up at the two ends, straightened through horizontally with the straightedge, and frequently levelled through. In all cases the screeds are fixed to suit the arrangement of tiles as shown on the plan supplied to the workman. When a panel is centrally fixed above a dado the panel is sometimes fixed first; but in any case accuracy in fixing the screeds is the essential point for attention. Fig. 15 shows the method of fixing screeds for a centre panel which will be fixed last. At times it is possible to secure the services of a carpenter who will make a frame with screeds to the dimensions required; otherwise the worker must construct and fix for himself. The screeds, when fixed, should be carefully compared with the drawing, to ensure fidelity in every detail. The sides should be plumb, and the horizontal screeds tested to see that they are at right angles to the vertical screeds. The same remarks apply to dados. The work is picked out, horizontal screeds are fixed level and parallel, and, where a series of small panels are inserted, a vertical screed is fixed occasionally as a check. When the work is finished the tiles

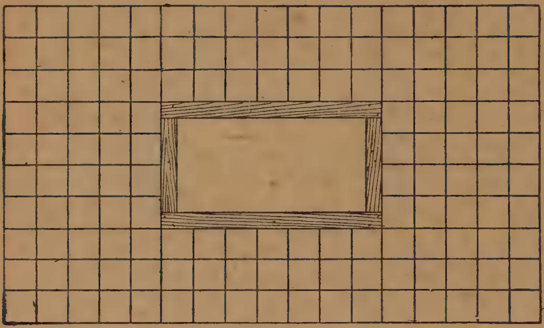


Fig. 15.—Screeds Fixed for Centre Panel

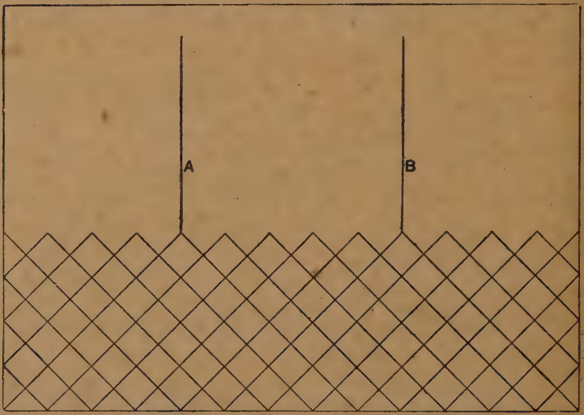


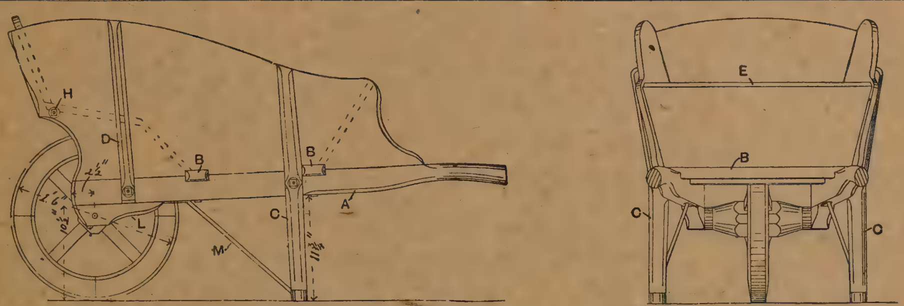
Fig. 16.—Diagonal Pattern of Tiling

can be cleaned off in the usual way; future cleaning is done with a sponge and clean water, polishing with a dry cloth.

The inexperienced workman will find it far more difficult to fix the ordinary 6-in. glazed tiles to a diagonal pattern (Fig. 16) than to a square. The valuable assistance derived from the use of screeds has to be sacrificed, and therefore greater skill is necessary, and far more attention must be paid to the work during construction. The fixing is begun by bedding the first course of diagonal halves perfectly level. It is then advisable to space out the wall as shown in Fig. 16, and to drop vertical lines from the ceiling to the apex of the tiles, as A B. The work is kept plumb, and course upon course is taken up, always easing the tiles slightly, if required, to keep the apex upon the vertical lines A B. The elevation of the tiles will then carry imaginary vertical lines cutting through the angles of the tiles in each course; and the hypotenuse lines will be less broken than if the work were executed without the perpendiculars. An important point that cannot be too strongly insisted on, is that the bedding must consist of exactly the right quantity for each tile.

Building a Wheelbarrow

In the wheelbarrow shown in side elevation by Fig. 1 the greater part of the load is carried over the wheel, thus taking much of the weight off the worker's arms. The barrow is slightly shorter than usual, and narrow enough to pass through a 2 ft. 6 in. doorway, this, together with the deep sides, being desirable features for ordinary use. Figs. 2 and 3 are back and front elevations respectively. Fig. 4 is



Figs. 1 and 2.—Side and Back Elevations of Wheelbarrow

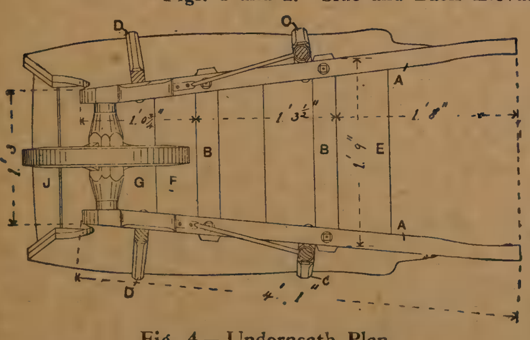


Fig. 4.—Underneath Plan

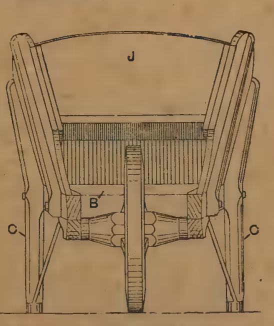


Fig. 3.—Front Elevation

a plan as seen from underneath, and Fig. 5 is a sectional elevation of the body. The frame should be of oak or ash, and the panels and bottom boards of elm or good red deal. The two strines A (main side members or "soles") are 4 ft. 1 in. long by $2\frac{3}{4}$ in. deep by 2 in. thick; the two sloats ("slots," "swords," or cross rails) B 1 ft. $10\frac{1}{2}$ in. and 1 ft. $7\frac{3}{4}$ in. long respectively by $2\frac{5}{8}$ in. wide by $1\frac{1}{8}$ in. thick; two legs C 2 ft. $2\frac{1}{2}$ in. long by 2 in. by 2 in.; and two standards D 1 ft. $8\frac{1}{2}$ in. long by $1\frac{1}{2}$ in. by $1\frac{3}{8}$ in.

The bottom frame is 1 ft. 3 in. wide over the strines at the front, and 1 ft. 9 in.

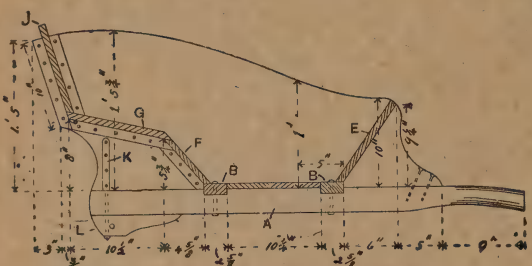


Fig. 5.—Longitudinal Section through Barrow

at the back of the hind sloat. The length on the centre line of the plan, from the front end of the strines to the front sloat, 1 ft. $0\frac{3}{4}$ in.; over the sloats 1 ft. $3\frac{1}{2}$ in.; from the hind sloat to the end of the handles 1 ft. 8 in. The strines and sloats are let into each other $\frac{1}{4}$ in. so that the latter stand $\frac{5}{8}$ in. above the former to come level with the top of the bottom boards, which run crosswise between the sloats, the frame being fixed together with $\frac{5}{16}$-in. bolts. The legs and standards are got out to the side splay obtained from Fig. 6; this splay is 5 in. in 1 ft. $5\frac{1}{2}$ in. The legs are tapered to $1\frac{3}{4}$ in. by $1\frac{3}{4}$ in. at the bottom, and $1\frac{3}{4}$ in. by $\frac{7}{8}$ in. at the top, the standards also tapering to $\frac{7}{8}$ in. thick at the top. The legs are fixed to the face of the strines with $\frac{3}{8}$-in. bolts, and the standards with $\frac{5}{16}$-in. bolts.

When setting out the side panels, the length of the various sections should be taken from the side line on the plan, and the height or width of the board from the side-splay line (Fig. 6). The panels are all $\frac{3}{4}$ in. thick, the back panel E, 11 in. wide, being housed $\frac{3}{16}$ in. into the side panels and nailed in position, being strengthened with corner plates at the top. The raised front is fixed to $1\frac{1}{8}$-in. by $\frac{5}{8}$-in. fillets screwed to the side panels, the board F being $\frac{5}{8}$ in. thick, and the other one G $\frac{3}{4}$ in. thick.

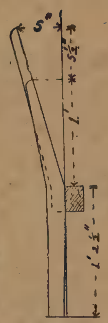


Fig. 6.—Leg

A $\frac{5}{16}$-in. long-bolt H extends across the front of the body, underneath the board G, embracing the side panels, to resist inside pressure. The front panel J, $10\frac{1}{2}$ in. wide, slides between fillets, and can be taken out to facilitate tipping the load. This panel should be battened at the back to prevent its splitting. At the front, a half-round strap-bolt K is fixed to the inner side of the side panels with screws, the bolt taking the front end of the strines and trunnion blocks.

The trunnion blocks L are 10 in. by $2\frac{1}{4}$ in. by 2 in., their back ends being fixed with screws, and the trunnion holes lined with iron tubing.

The legs are strengthened with stays M of $\frac{7}{16}$-in. round iron, the lower end being welded to the hoop on the leg.

It is best to buy the wheel from a wheelwright. It is 1 ft. 6 in. high "in the wood"—that is, without the tyre; nave, 1 ft. long by $3\frac{1}{2}$ in. by $3\frac{1}{2}$ in.; one spoke, $3\frac{1}{4}$ in. by $1\frac{1}{4}$ in.; and the other one $1\frac{1}{4}$ in. by $1\frac{1}{4}$ in.; felloes, $2\frac{1}{4}$ in. by $2\frac{1}{4}$ in.; tyre, $1\frac{3}{4}$ in. by $\frac{5}{16}$ in.; trunnions of $\frac{5}{8}$-in. iron. The wide spoke is mortised through the centre of the nave and the square spoke at right angles, the wide spoke being then dressed to $1\frac{1}{4}$ in. in width at the ends where it enters the felloes. The tangs at the extreme ends of the spokes should be $\frac{7}{8}$ in. in diameter.

The Gramophone: The Machine and Its Cabinet

THE disc type of talking machine commonly known as the gramophone is now to be found in the majority of homes. It was originally the invention of Mr. H. Berliner, of Washington, U.S.A., and its then purpose was to demonstrate Prof. Bell's discovery that the vibrations caused by any series of sounds could be "written" by a vibrating point on a suitable material, and the same series of sounds reproduced by another point travelling over the inscription so made. As most readers are aware, the modern talking machine is of two distinct types — the "cylinder" machine, known as a phonograph, invented by Edison, in which the record is cylindrical in shape, and the "disc" machine called the gramophone, in which the record is a disc.

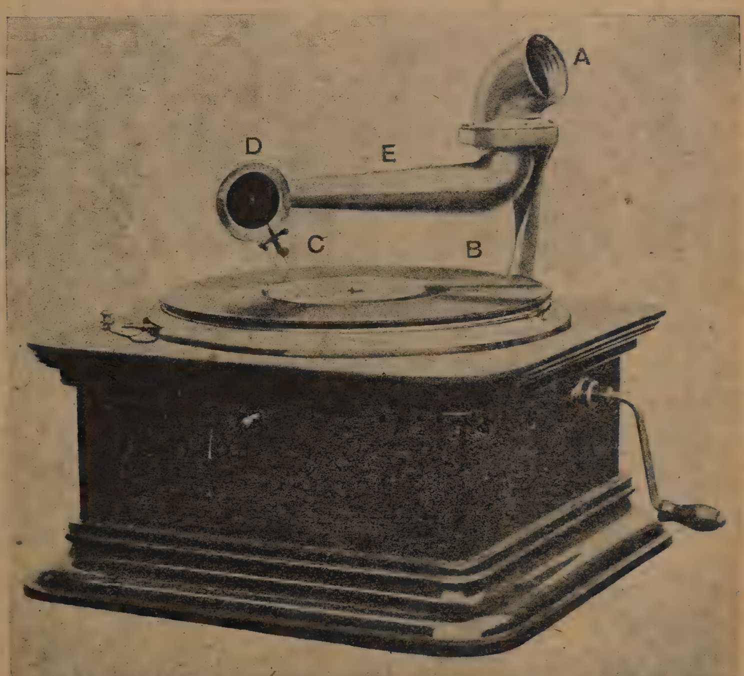
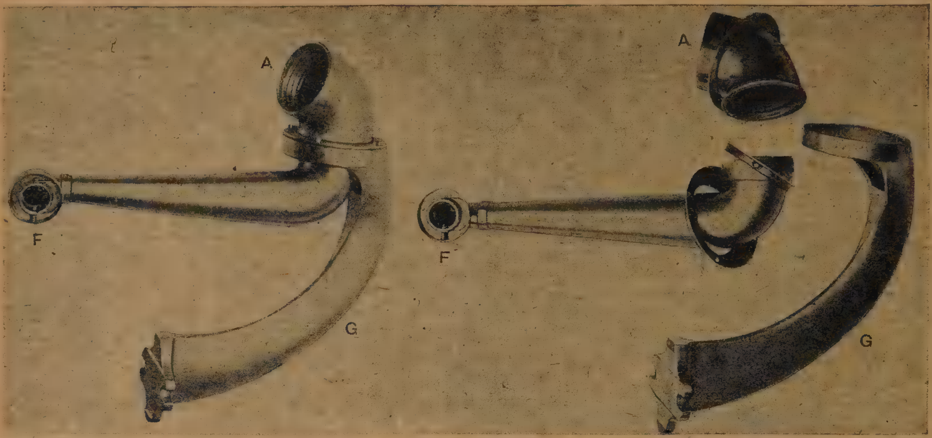
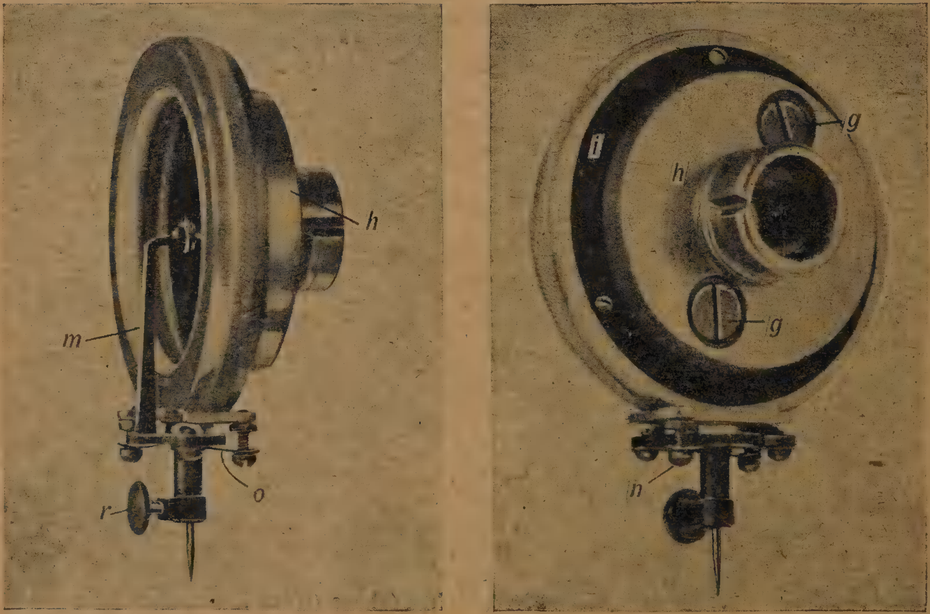


Fig. 1.—Gramophone (Horn Removed)

It is not proposed to discuss the phonograph or cylinder machine in this chapter, since it tends to be used less and less, and during the last year or so has been left



Figs. 2 and 3.—Tone-arm and Bracket



Figs. 4 and 5.—Two Views of Gramophone Sound-box

hopelessly behind by its rival the gramophone. In both types of machine, however, the essential principle is the same, namely, a "record" made from a wax-like composition is rotated under a needle-point, the needle running in a continuous trough that is smooth but waved. This trough or line was originally engraved upon the record by the action of sound waves, and it now imparts to the needle a series of sidewise movements which are conveyed to a diaphragm or drum-head, and caused to produce sound waves resembling those that originally impressed themselves upon the record.

The modern gramophone is truly a *gramophone*—from *grapho*, I write, and *phone*, sound. The original *gramophone* etched its records on an acid bath; and the original *phonograph* indented its records on a metal foil. But, nowadays, any disc machine is known as a gramophone.

A TYPICAL GRAMOPHONE DESCRIBED

Fig. 1 is a photograph of a typical gramophone, minus the well-known horn, which fits into the aperture indicated by A. A record B is shown in position ready for playing; a clockwork motor attached to the under-side of the box lid, and wound up by means of the handle shown to the right, gives a rotary motion to the disc record, which travels under a needle-point C clamped to the sound-box D. The line or groove engraved on the record is of **V** section, smooth throughout, but in itself sinuous or wavy, and, as the disc revolves, the needle is impelled rapidly from side to side horizontally, and its movements are transmitted through a fulcrum to what is known as the diaphragm, which may be a disc of mica or glass occupying the face of the sound-box D. The movement of the diaphragm, an infinitely rapid vibration, disturbs the air and forces sound waves along the curved arm E (the "tone-arm"), through the joint and into the trumpet, which amplifies the sound. The tone-arm E (Columbia Co.'s pattern) is jointed in such a way that the sound-box is free to move up and down or left and right, and the socket to which the trumpet is attached can make a complete revolution. Figs. 2 and 3 show the tone-arm separate from the machine; at F is attached the sound-box; G is the bracket by means of which the tone-arm is supported from the side of the case, where it is held by two screws with milled heads; and A is the trumpet attachment. Details of the joint are clearly shown. Figs. 4 and 5 show the sound-box almost full size, this being of the

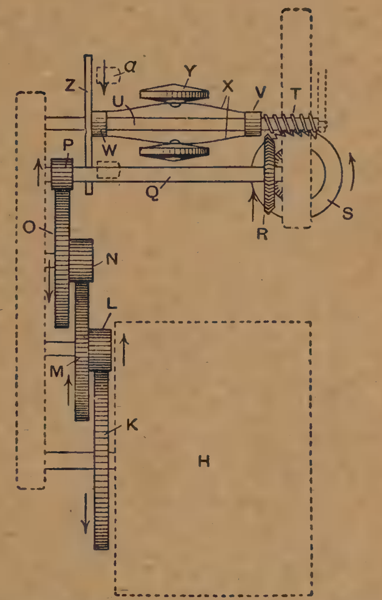


Fig. 6.—Diagram of Gramophone Driving Mechanism

Columbia "Regal" pattern, excellently contrived and skilfully made.

The motor that rotates the disc is, as already mentioned, screwed to the under-side of the lid or top of the box, and is wound up by means of the handle shown. The vertical spindle driven by the clockwork motor projects through the lid of the case and carries a blunt brass cone. The baize-covered metal table upon which the record lies has a central boss projecting downwards, this boss being coned internally to fit friction tight upon the brass cone carried by the motor spindle; thus, as the spindle revolves, the metal disc or table revolves with it.

On lifting the lid of the case the clockwork motor is brought into view (see Figs. 7 and 8 and also the diagram, Fig. 6, in all of which the letter references corre-

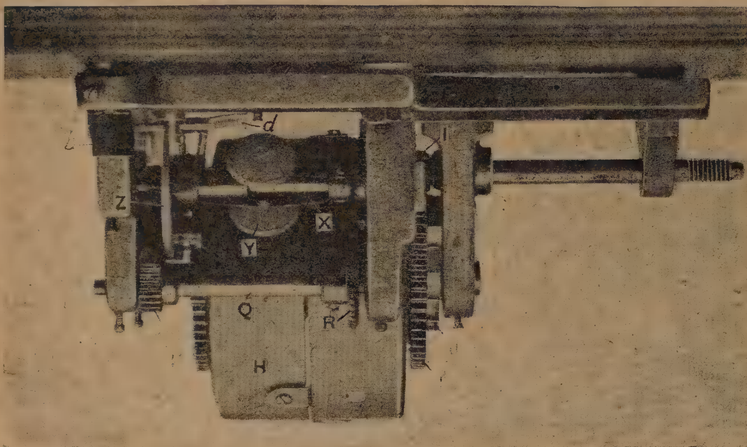


Fig. 7.—Front View of Gramophone Motor Attached at Top to Lid of Cabinet

spond). While its details will vary with the type and price of the machine, its general arrangement is practically always the same. A powerful mainspring is coiled around a horizontal spindle enclosed within the case H, and wound up, by the handle shown, through a pinion and toothed wheel I and I′. This allows of a continuous forward wind, a very great advantage, the handle rotating in the same direction as the first driven wheel M of the train. A click-wheel arrangement J prevents the spring unwinding when pressure on the handle is released. The power of the coiled spring is exerted upon toothed wheel K, and the problem that now presents itself is how to increase the speed to give about seventy-five revolutions per minute for needle-played discs, at the same time ensuring that it be uniform and smooth. Violent variations would be fatal to the effect, and the speed must be easily controllable simply by moving a lever. The problem is solved by very simple means. There is a train of gear wheels consisting of three pairs, each designed to increase the speed. The large wheel K (which is shown to the left of the mainspring H), with say sixty-five or seventy teeth, meshes with a twenty-leave pinion L, mounted on the same axle as wheel M, which will be only slightly

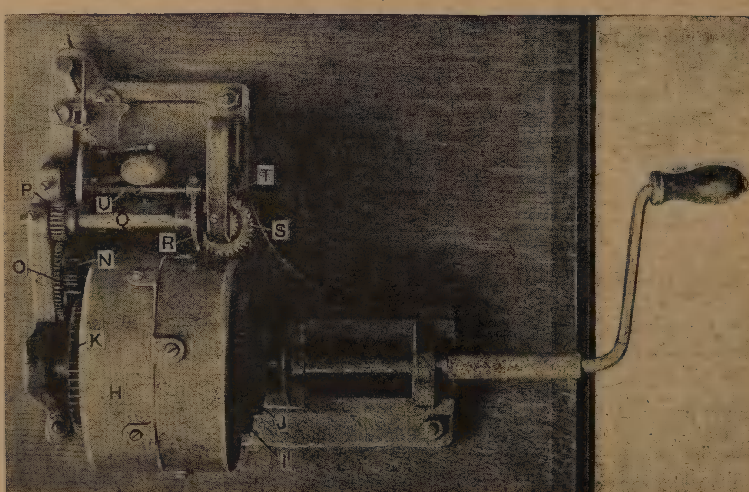


Fig. 8.—Underneath View of Gramophone Motor

smaller than K. M drives a fifteen or eighteen-leave pinion N mounted on the same axle as the toothed wheel O, of about fifty teeth, which meshes with pinion P, that is fast on a horizontal axle Q which at the other end drives the vertical spindle by means of bevel gearing R R′. Thus the plane of rotation is changed from the vertical to the horizontal. There is no further gearing to increase the speed, but on the vertical spindle there is a worm wheel S, which meshes with worm T by means of which the brake blocks of tough felt *a*, thus adding to the resistance and perceptibly slowing the motor.

The governor is also the means by which the motor is started, stopped and regulated. Fig. 10 is a photograph of the control levers fitted on the upper side of the lid. To start the motor, lever 1 is pushed over into the position shown and in so doing it turns the crank *b* (see Fig. 9), which takes the pressure off the spring arm *c* and allows the coiled spring *d* to pull the brake away from the friction disc.

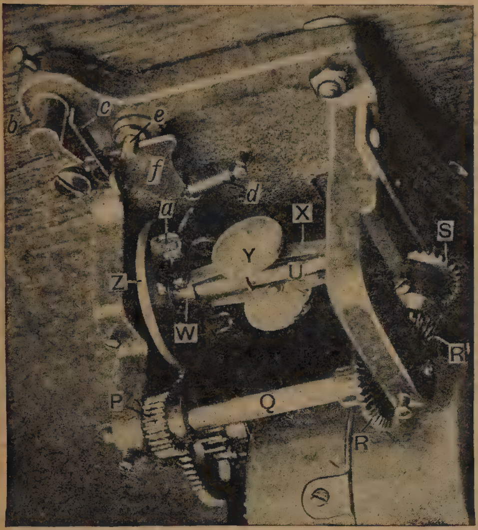


Fig. 9.—Governor of Gramophone

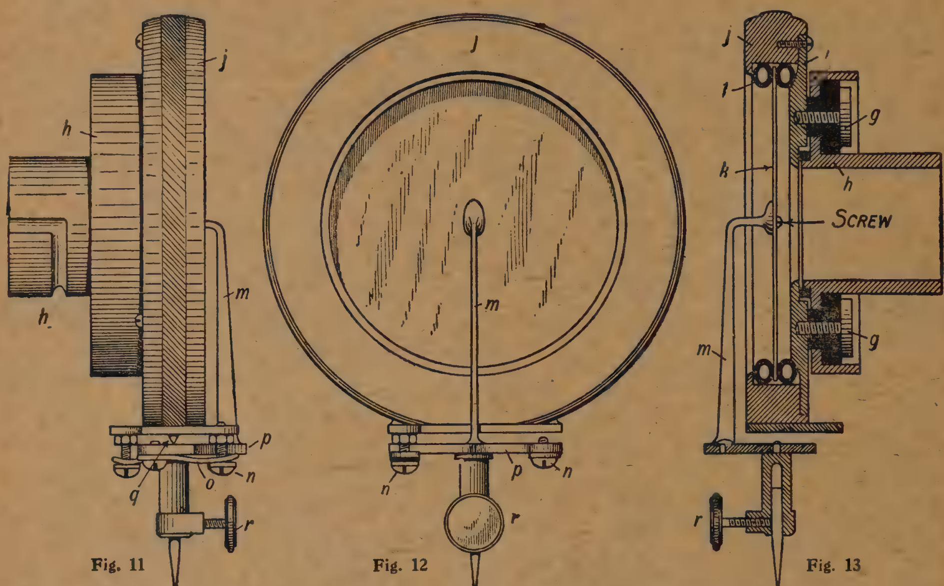
Fig. 10.—Control Levers of Gramophone

governor shaft U is driven. The governor (see also Fig. 9) is the most ingenious part of the motor. V and W are two brass collars connected together by flexible strips of steel or springs X carrying rubber weights Y. Since the governor shaft is driven by worm gearing straight off the motor spindle the speed of the one is in strict relation to that of the other. The greater the speed of the governor shaft the wider do the weights fly out, thus pulling collar W, to which is attached disc Z, and which slides freely on the shaft, towards collar V, which is fixed to the shaft. In this way the friction disc Z is drawn up against two

Until this moment the friction disc has been held stationary by the brake, but on the removal of the pressure the motor at once starts working. The control lever 2 (Fig. 10) also acts by applying pressure to or withdrawing pressure from the friction disc. When lever 2 is moved, the semicircular pin *e* moves the bell crank lever *f*, thus applying or releasing the brake, and thereby reducing or increasing the speed.

In the event of breakage of the main driving spring, a new one is easily fitted if the following instructions are carefully observed: First allow the motor to run down completely (if any power

remains in the spring), and then detach the motor from the case or framework. Proceed to take the motor to pieces, separating the frames by removing the pillar nuts or forcing out the pegs. The motion work is taken out wheel by wheel, the relative positions being noted. The spring is usually contained in a drum, on one side of which will be found an aperture by which the loose cheek may be prised out, thus exposing the spring. Turn the axle backwards to detach the the barrel and spindle will engage with the slots when the wire is released. Ease off the wire little by little, pushing the spring into the barrel meanwhile ; do not release the wire until the coil is as far in as possible. Finally, detach the wire, when the spring will at once expand into the drum. When in position, the axle is inserted and turned until the detent engages the spring. The drum is now firmly held, and the axle and spring revolved until the drum detent finds the



Figs. 11 to 13.—Side View, Front View and Vertical Section of Gramophone Sound-box

detent from the inner end of the spring, and remove the axle ; a slot is usually provided through which the detent may be withdrawn. The fractured spring is now carefully removed, levering it out by degrees until its coils can be cramped or wired up. If the spring is withdrawn at one operation it will violently uncoil, and may wound the hands or damage the work. Hold both the drum and the spring in a cloth.

The new springs are sold compressed and wired up ready to insert in the drum. Before inserting a wired-up spring, see that it is right way about, so that the catches of aperture at the outer end of the spring. Before replacing the drum end, completely fill it up with a mixture of graphite and unscented vaseline, forcing the mixture among the spring coils. The machine can now be re-assembled.

When dealing with springs that are not confined within a drum, they should be attached to the framework by their outer end ; generally a loop is provided to fit one of the frame pillars. The insertion of this kind of spring is even simpler than the process explained above, the confining wire being cut after the machine is put together. After the replacement,

wind and run the motion several times to distribute the lubricant within the drum and coils.

The Sound-box, Speaker, or Reproducer.—The sound-box diaphragm of a talking machine is essentially the source of its voice. The minute inequalities in the track of the swiftly-running record provide the energy that throws the thin and resilient membrane (the "drum-head") into infinitely rapid vibration; the contiguous air is necessarily set in rippling disturbance, and so the impression of sound is conveyed to the ear. Diaphragms are commonly circular in form, but not necessarily so. Any thin and elastic solid substance will reproduce sound from a record, but glass, mica, carbon, and hardened metal are in general use, the two first mentioned being the most commonly employed. Discs cut from hard-rolled visiting or playing-cards will reproduce sound quite tolerably for a time, but they soon "tire." Even mica and glass tire in time. Therefore, after several months of constant use, it is advisable to replace any diaphragm. Glass and mica discs are stocked by gramophone dealers. The common glass discs are often too thin and flimsy; an average parcel will be found to vary in substance, and only the stouter ones should be selected. A glass of $1\frac{1}{2}$ in. to $1\frac{3}{4}$ in. in diameter should not be thinner than a light visiting-card, and those of 2 in. and upwards must be proportionately thicker. This applies also to mica and carbon discs, although these are more often of correct weight. A too flexible diaphragm not only plays feebly, but it "blasts" in the loud passages. A flimsy diaphragm is readily detected by holding the sound-box in such a manner as to reflect the light from its disc; the thumb-nail should now be lightly pressed on the stylus; there should be but little spring in the disc. If the latter is "soft," and readily compressed to concavity, it should be replaced.

Setting a diaphragm is a simple operation, but modern disc sound-boxes vary in design; among the simpler ones are those into which the diaphragm is inserted from the front, it being backed and faced by stout rubber rings. In more elaborate patterns it is necessary to unscrew the parts to change the discs. Regarding the former, there is little to be said except that due care must be taken to seat the mica evenly, and keep it from contact with the cell. The better quality of speaker must, however, be dismounted, and, as typical of its kind, the Columbia Co.'s "Regal" sound-box will be taken as an example. This is shown photographically in Figs. 4 and 5, while, in addition, full-size elevations and cross section are presented by Figs. 11 to 13. In dismounting a sound-box of this pattern, first withdraw the two screws *g* (their rubber washers are shown in solid black), and take off the flange *h*. Note the rubber insulating ring (shown in solid black) between the flange *h* and the metal ring-plate *i*, to prevent any metallic contact between the two.

Remove three small screws and detach the ring-plate *i* from the body *j*. Unscrew the small central diaphragm stud, being careful not to lose it. Now push out the diaphragm *k* and rubber gaskets *l*; the latter are, in this case, small-bore tubes, and if these are found to have lost their elasticity, they must be renewed. The company supplies spare gaskets, cut to exact length and scarfed at the ends, to make a close fit within the cell. Similar tubing cannot readily be procured elsewhere. Cut the rubber, fit both lengths accurately, and insert the new diaphragm (of stout, clear, and unsplit mica), set it centrally on the front gasket, and back up with the other. Some people prefer to attach the disc to the front rubber by a trace of seccotine, to avert the possibility of its coming in contact with the metal wall of the cell while screwing the latter together; but it is better not to employ adhesive with this type of speaker.

Now secure the diaphragm finger *m* to the disc by its central screw, and melt a fragment of hard beeswax into the joint by the touch of a hot wire. Carefully re-assemble the rim and body of the fitting, and the diaphragm should then be found evenly nipped between the com-

pressed gaskets. In a good light, examine the face of the disc, and observe that it is not being subjected to any strain. Move the needle-bar gently to test this. If the mica shows convexity or concavity, the tension screws *n* must be carefully readjusted until the disc lies flat, its set being determined by its own elasticity. Unless absolutely necessary, any alteration of the tension screws should be avoided. If, however, they must be adjusted, be sure to slacken one to an equal extent with the tightening of the other; half a turn of each screw makes a considerable difference in the set of the finger end, and a complete re-tuning of the sound-box would give some trouble. The screws *n* and springs *o*, combined with the needle-fitting *p*, which fulcrums on the two points *q*, constitute the tension arrangement. The needle is held in its hole by clamping screw *r*.

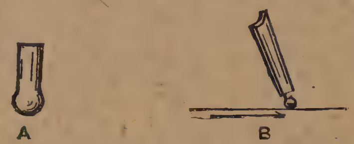


Fig. 14.—Ball-stylus for U-groove Discs

Although some brands of needles are advertised to be utilised for several discs in succession, it is unadvisable to use any needle twice. A needle examined with a microscope after use shows facets on each side. Such wear cannot be entirely avoided; but if employed twice these facets will develop into ragged cutting edges, the extreme point will break away, and the record must immediately suffer by the tearing action of the needle, now become a scraping tool. Thorough dusting of the groove removes the sharp grit ever present in the air (particularly in dry weather), and also the impalpable but destructive powder of hard steel, ground from the last-used needle.

The Pathé and other U-groove discs ("phonograph cut") are played with a ball-ended sapphire stylus, and the dot-and-dash record acts on this in an up-and-down direction instead of by side-to-side impulses given by the wavy V-track; their running direction is from the centre outwards. In the case of the needle-played discs ("gramophone cut"), their running direction is inwards to the centre.

Sapphire is only second to the diamond in hardness, and a ball or button made of it will play many hundreds of records without becoming worn. Directly, however, its high polish is lost, it rapidly deteriorates, scraping and damaging the track more and more.

Reproducers employed on U-groove discs have ball styli as shown at A (Fig. 14). When these are set to trail slightly (relatively to the direction of the cylinder's revolution), as at B, a full half-turn will often suffice to present a new surface. When the stylus is set upright (or radially) on the cylinder, no resetting is possible, as the bottom of the ball rests in the groove, and when worn it must be renewed or repolished. To turn a stone in its setting, the lever is removed from the body of the reproducer, warmed sufficiently to soften the cement, the stone gripped in small forceps and deftly turned as required.

Remedying Rattle.—A sound-box occasionally gives trouble by rattling, in which case it will probably be found that most of the vibration occurs at the central screw, and is easily remedied as follows: First firmly secure the back nut, if any; melt a small fragment of hard beeswax round the junction by a touch with a heated wire; the wax will firmly adhere to the mica and to the metal of the finger disc, consolidating the two for an indefinite time. If the rattle is not at once subdued by this, the speaker must be overhauled and the following points given attention.

The mica disc should be stout and sound, showing no cleavage laminations. It must be of a size to fit easily within the cell, and when screwed into position it must not touch the metal of the box at any point, but be firmly and evenly gripped between the rubber tube gaskets. The gaskets themselves should be tested. If they have lost their pliancy they should be discarded and replaced by new ones.

See also that the large rubber buffer supporting the tone-arm socket has not become hardened by age. If not too far gone, it may be renewed to some extent by steeping in warm water, for which purpose it must be detached and the central tube removed. Work the rubber in the hands while warm, or beat it lightly on a flat surface with a wooden mallet.

In re-assembling the parts see that the socket of the swan neck fits without shake within the **T** of the tapered arm. Treat the part liberally with unscented vaseline; the viscosity of this lubricant will effectually subdue rattle at this point, and it is recommended also for the larger joints of the articulated arm and trumpet.

Lubrication.—The whole of the wheel-work should be lubricated with a smoothly mixed paste of pure graphite (plumbago or blacklead) and unscented vaseline. Force this into all bearings and the cog teeth with a stick. The mixture not only prevents over-rapid wear, but its thick consistency much subdues any humming. One thorough dressing will last many months if occasionally a few drops of good machine oil are sparingly applied. Price's cycle oil, the heavy B quality, or "Axeline," is suitable. After greasing, wind the action and run it down once or twice to distribute the lubricant.

The tone-arm and trumpet-joints of a gramophone should be smeared with unscented vaseline, the surplus being wiped off when the parts are re-assembled. This arrests vibration and renders them "sound-tight."

Speed Regulation.—It is easy to determine the correct speed after a little experience. When records are run too fast this has the effect of augmenting the sound, but it also raises the pitch, not only to sharpness, but often to the extent of several tones. The novice should in the first place count the revolutions of his machine, in order to accustom himself to what is required and what to expect from records. He should periodically verify the pitch of the machine, adjusting the machine by any of the following methods: (1) Attach a piece of stamp-paper to the disc and check its revolutions by the second-hand of a watch; or (2) lightly scribe a straight line with a sharp instrument on a waste record (longitudinally on a cylinder or radially on a disc); run this on the machine with the sound-box in position. The scribed line will produce a distinct tap at every revolution; check the tapping by the watch. The Pathé type (or "phonograph cut") should make 90 revolutions per minute, or thirty taps in twenty seconds. Needle-operated discs, at 75 revolutions per minute, should tick off twenty-five in twenty seconds. (3) The pitch of one sustained note in any record being known, it may be brought into unison with a tuning-fork or pitch-pipe.

Choosing a Gramophone. — The machine must be substantial and the motor smooth running. The vibration should be confined as far as possible to the diaphragm. Tremors, such as are caused by a shaky or ill-balanced motor, or by a flimsy framework, confuse the sounds issuing from the trumpet; and to this fact is due the harsh and unpleasant tone of inferior instruments. Other things being equal, a solidly built machine will give both a more powerful and more refined tone than one of light make.

In choosing a machine, first examine the exterior fittings and general equipment. If moving or detachable parts are observed to be carelessly put together, so as to rattle when lightly shaken, the machine is best passed over. Test the turntable of the disc machine for side play; it should be rigid. Now wind the motor fully, and allow it to run (without a record) at its normal speed, 75 revolutions per minute for the needle disc and 90 for those played with a sapphire ball-stylus. Choose the instrument which makes the least audible and most regular humming. Place the finger-tips on any part of the frame or case and discard the machines which give evidence of tremor. If the governor balls are not of similar weight, or if their springs differ in temper or substance, the combination will not spin evenly, but will jump like an ill-mounted flywheel. The governor revolves

fast, making from 800 to 1,500 revolutions per minute, and the smallest error of balance is magnified to a vigorous rippling tremor at this speed, causing either a general harshness of tone or imparting an irritating tremolo to the reproductions. At some little distance from, and not quite opposite to, the trumpet mouth, the general effect when the instrument is working should be musical and pleasing, loud and full without being harsh, there should be no rippling or pulsation of sound, and the whole range of tone should be free from sharp harmonics, metallic clangour, or small incidental discord. The silent and continuous-winding action should be insisted on. By this arrangement the key revolves almost noiselessly in the running direction of the large gear-wheel, and consequently the machine may be wound up while it is playing. This makes a large and elaborate motor unnecessary. Large machines do not necessarily play better or more powerfully than well-made small ones, the only advantage of the former being the longer run and proportionately longer wind, though, of course, substantiality counts for something. When the motor has a reversed wind it must be stopped and wound fully after each selection.

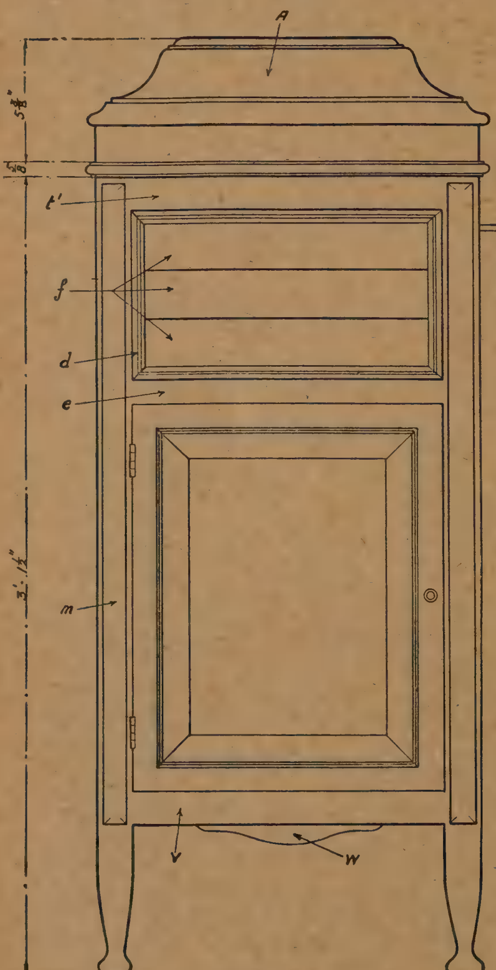


Fig. 15.—Elevation of Pedestal Gramophone Cabinet

A PEDESTAL GRAMOPHONE CABINET

Figs. 15 to 20 show a popular design of gramophone cabinet, and in setting about the task of making this, the wisest plan is to purchase the gramophone fittings first. These fittings comprise the motor (1), motor handle (2), turntable (3), speed regulator (4), motor stop (5), tone arm (6), sound-box (7) and needle-cups (8). Nos. 1 to 5 are generally sold in the set complete. The type of motor must be decided upon before starting to build the cabinet, as the design of the cabinet depends on the depth of the motor.

A good motor and sound-box are very essential. A double- or triple-spring motor should be chosen which runs silently (a motor with a fibre gearing giving the best results), and one which sets up no oscillation of the turntable when revolving (a very common fault).

Gramophones without the old type of metal or wood horn fixed above the machine are often called "hornless," but this is incorrect; the term ought to be "inverted horn." This type of machine, in addition to dispensing with the unsightliness of the horn, adapts itself easily to the construction of a hinged top A, made as sound-proof as possible and enclosing the sound-box and turntable, thus smothering to a great extent the scraping sound caused by the friction of the needle and the record when revolving.

The design shown embraces an inverted horn made of timber and presspahn, the two sides of the horn of timber *a*, and the top and bottom of presspahn *b*, the latter being a type of compressed paper with an excellent finish used chiefly for electrical insulation, and lending itself splendidly for the purpose, being flexible and giving a good mellow tone to the sound waves passing through the horn. The two timber sides are shaped to *a*, the wide ends being screwed to the louvre-frame *d*, which is rebated to receive them at position *c*, and the narrow ends to the fixed position D^4 of top *D*, the screws being arranged in such a position that they will be afterwards covered by the flange of the tone-arm base. The presspahn *b* is pinned to the top and botton of the timber sides and all four edges covered with tape and glued on the outside to make it sound-proof.

The louvre-frame *d* is dovetailed together with the front mould mitred and the frame fitted into the opening of the cabinet framework made to receive it, being fixed to the front intermediate rail *e* by screws, from underneath the rail. Inside the louvre-frame are fitted three pieces of wood shaped to *f*, being held in position by a screw put through the side of the louvre-frame on which they rotate. They thus form a louvre by which the volume of the sound can be regulated, the three louvres being coupled together by a connecting link *g* made of sheet metal about 20 S.W.G., three lugs being let in flush and screwed to one end of each louvre, making them all movable together.

The motor is suspended by rubber-insulated bolts from D^3, the hinged part of top *D* being in such a position that the turntable spindle 1[a] of the motor is central between the two sides and 7½ in. back from the front of the top front rail t^1, a hole being

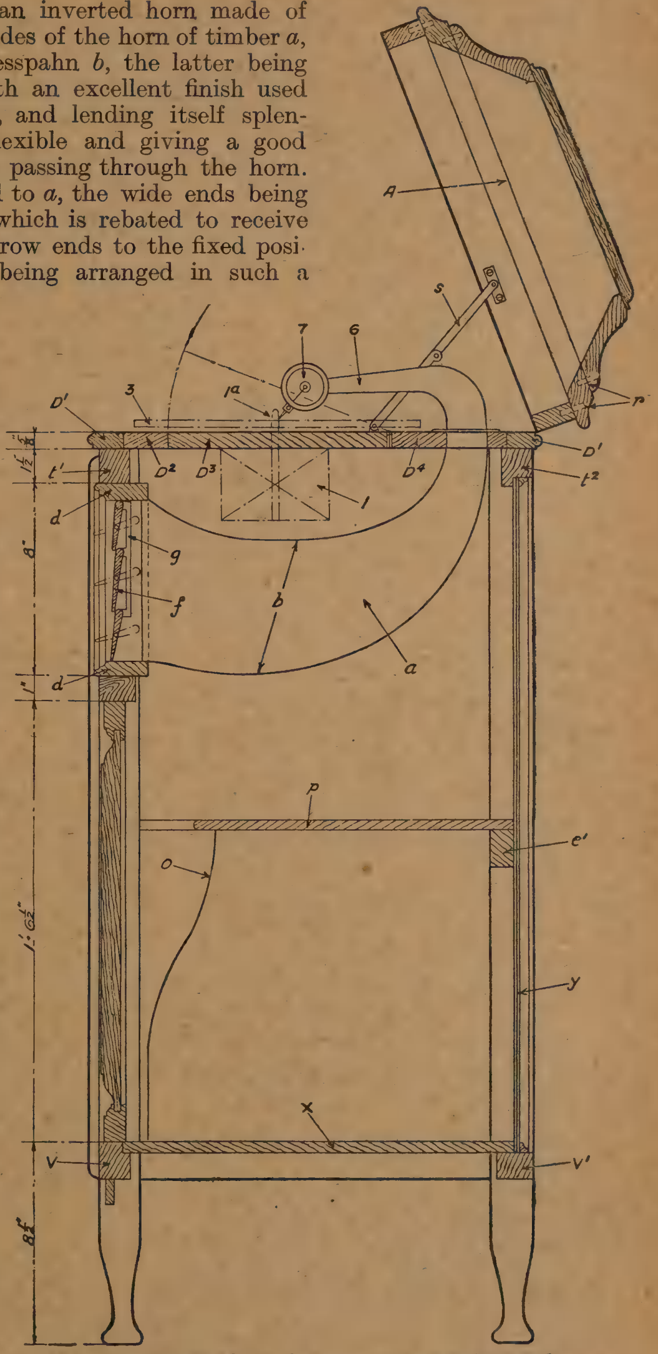


Fig. 16.—Detail Vertical Section through Pedestal Gramophone Cabinet

bored to allow the spindle to protrude with clearness. The advantage of a suspended motor on a hinged top is that on removing the turntable and motor handle this top can be raised and the motor easily exposed for lubrication, examination, etc., the weight of the motor keeping the top down without any fastener, though it is desirable to fit the lid with a flush ring-lift k, which is hidden by the turntable. The motor handle extends to the outside of the cabinet on the right, a hole being bored in the side panel to allow it to connect with the motor. This handle must be removed before the motor lid D^3 can be raised. The motor stop and speed regulator are fitted on the hinged motor lid.

The position of the tone-arm is decided by its length; fit the tone-arm with sound-box and needle, and place the point of the needle at the centre of the motor spindle, thus determining the position of the tone-arm base. Cut out of top D^4 a hole at the position thus obtained, which hole must be the same diameter as

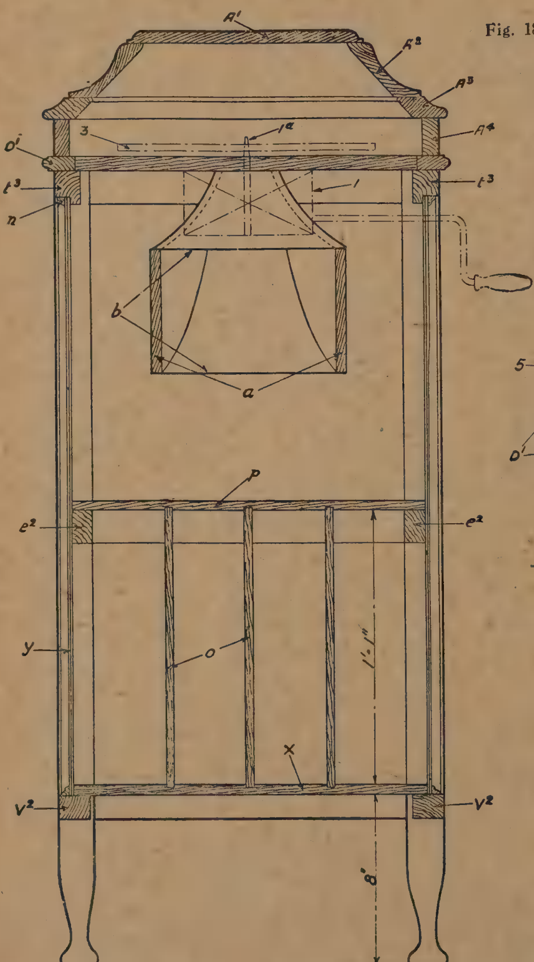
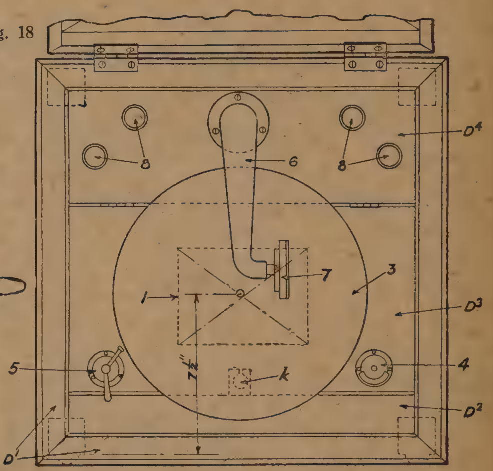
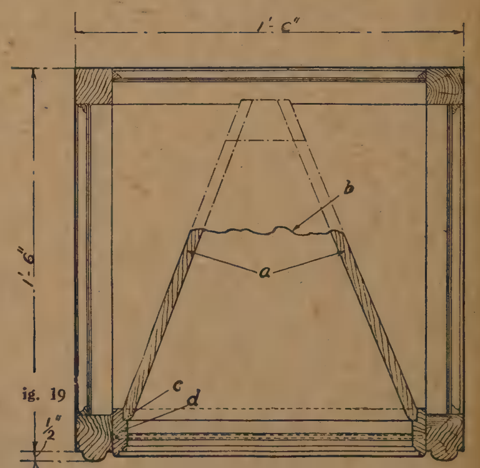


Fig. 17.—Vertical Section through Gramophone Cabinet at Right Angles to Fig. 16

Fig. 18





Figs. 18 and 19.—Plan with Lid Up and Horizontal Section through Horn

the inside of the tone-arm and must connect up directly with the horn fastened underneath.

The building of the cabinet is started by making the framework, the top rail t^1, t^2, t^3 of which should be dovetailed, and the remaining rails all tenoned and mortised into the corner pillars *m*. The two front pillars are designed with a projecting mould which can either be worked out of the solid timber or planted on (preferably the former). The top mould D^1 is afterwards fitted, followed by the louvre-frame complete with louvres and horn

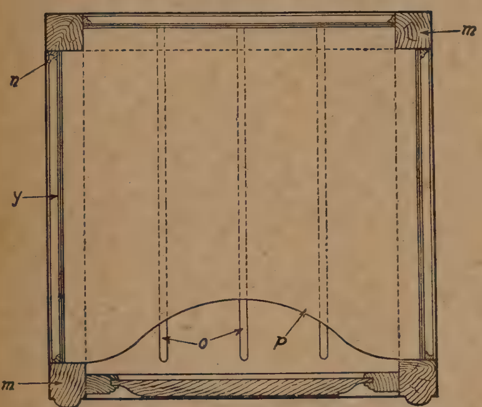


Fig. 20.—Horizontal Section of Gramophone Cabinet above Shelf

attached. The side panels and back panel are best in three-ply 3/16 in. or ¼ in. thick, which fit in between the corner pillars and top and bottom rails t^2 and t^3, and V^1 and V^2, resting against the intermediate rails e^1 and e^2, and are secured by a small mould *n* pinned round the panels in the corners.

The cupboard door is fitted and hinged and held in position by a small ball catch fitted in the door top rail. The inside of the cupboard is fitted with three divisions *o*, and a shelf *p* for the classification of the records, all having shaped fronts.

The top of the cabinet is built up from a series of moulds A^2, A^3, A^4, mitred at the corners and dowelled together *r*, A^1 being finally pinned to A^2. This top is hinged to the back top mould D^1, and when opened for the changing of the record is held in position by a brass quadrant *s*.

Gramophone fittings are nickel-plated, and the whole of the cabinet fittings should also be nickel-plated to match.

This machine may be used as a Pathéphone by the adoption of the Pathé sound-box and connection, in place of, or in addition to, a gramophone sound-box.

Material Lists for Pedestal Cabinet.—The following lists show the materials required:

CABINET FITTINGS

1 3″ Side and top plate quadrant (left hand)	
1 pair 2½″ Brass butt hinges for cabinet top	
1 pair 2″ Brass butt hinges for motor lid	Brass fittings and screws to be nickel plated.
1 pair 1½″ Brass butt hinges for door	
1 ¾″ Cabinet door-knob	
1 1″ Ball catch	
1 1″ Flush ring-lift	

2 sheets presspahn 1′ 8″ × 1′ 2″ × 1/16″.

TIMBER (FINISHED SIZES)

2	Front corner pillars	3′ 1½″ × 2¼″ × 1¾′
2	Back corner pillars	3′ 1½″ × 1¾″ × 1¾″
1	Top front rail (t^1)	
1	Top back rail (t^2)	
2	Top side rails (t^3)	1′ 6″ × 1½″ × 1¼″
1	Bottom front rail (V)	
1	Bottom back rail (V^1)	
2	Bottom side rails (V^2)	
1	Front intermediate rail (e)	
1	Back intermediate rail (e^1)	1′ 6″ × 1½″ × 1″
2	Side intermediate rails (e^2)	
4	Top moulds (D^1)	1′ 7″ × 1½″ × ⅝″
1	Top piece (D^2)	1′ 4″ × 2″ × ⅝″
1	Top piece (D^4)	1′ 4″ × 5″ × ⅝″
1	Motor lid (D^3)	1′ 4″ × 9″ × ⅝″
2	Louvre-frame pieces (d)	1′ 2½″ × 2¼″ × ⅝″
2	Louvre-frame pieces (d)	8″ × 2¼″ × ⅝″
3	Louvres (q)	1′ 1½″ × 2½″ × ⅜″
1	Cupboard shelf (p)	1′ 4½″ × 1′ 3½″ × ½″
1	Cupboard bottom (x)	1′ 4½″ × 1′ 4½″ × ½″
3	Cupboard divisions (o)	1′ 1½″ × 1′ 3 × ¼″
2	Side panels (y)	2′ 4½″ × 1′ 3″ × 3/16″ or ¼″ three-ply
1	Back panel (y)	
2	Door styles	1′ 7″ × 1½″ × ⅞″
2	Door rails	1′ 3″ × 1½″ × ⅞″
1	Door panel	1′ 4″ × 12½″ × ⅞
1	Front bottom rail shaped piece (w)	9″ × 1″ × ⅜″
6	Panel moulds (n)	2′ 5″ × ⅜″ × ⅜″
6	Panel moulds (n)	1′ 3″ × ⅜″ × ⅜″
2	Horn sides (a)	1′ 3″ × 9½″ × ½″
1	Top (A^1)	11″ × 11″ × ½″
4	Moulds (A^2)	1′ 5″ × 4″ × 1″
4	Moulds (A^3)	1′ 7″ × 2½″ × 1″
4	Moulds (A^4)	1′ 6″ × 1¾″ × ¾″

A JACOBEAN CABINET FOR GRAMOPHONE

A particular feature of modern gramophone makers is the production of "period" models in which the cabinet is designed along the lines of some historic style to harmonise with the existing furniture of a room. Figs. 21 to 30 show a cabinet on Jacobean lines intended to be finished in a dark antique shade now so much in vogue for oak furniture.

One of the chief essentials of a gramophone cabinet is that it should be rigid and firm, confining all vibrations as far as possible to the diaphragm of the reproducer or sound-box; and in this respect at least the accompanying design should prove satisfactory. Figs. 22 and 23 show a front elevation and vertical section respectively, Fig. 23 giving the general arrangement of the motor, turntable and the wooden horn or sound amplifier.

Fig. 21.—Gramophone Cabinet in Jacobean Style

It will be as well to start the construction by making the lower stand or table portion. The legs, of which there are five, may be bought ready-made or may be turned at home. Once the legs are prepared there is little difficulty about the stand, this being framed together in the ordinary method of table construction.

The pattern for the carved stretcher rails is shown enlarged in detail by Fig. 26, and is adapted from a similar feature in an old chair in the Victoria and Albert Museum. It may be noted that, if desired, these carved rails may be substituted by plain straight rails as at the sides. The upper front rail runs through from end to end, the middle leg being bridled over it. When the table part is glued together and cleaned up the moulding A (Fig. 22)—shown larger in Fig. 28—can be mitred round and secured to it with screws, being further strengthened with glue blocks.

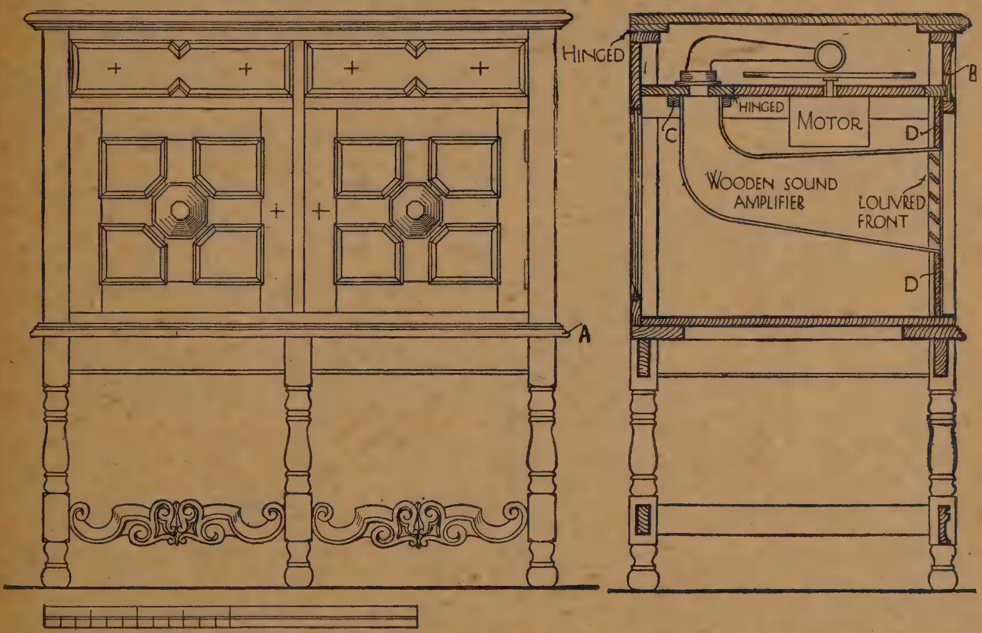
Upper Cabinet.—The upper cabinet can then be taken in hand. The ends are panelled (Fig. 25); the bottom, which may be solid, but would be better also framed, is lap-dovetailed to them; and top rails jointed to them in a similar manner at the front and the rear. The central division is also framed together, having a wide rail at the top (see Fig. 24).

The back of the cabinet is panelled, and it should be remembered that in a piece of furniture of this kind the back should be constructed as well, and of as good material, as the rest of the work. The

left-hand portion of the upper carcase is quite straightforward in character, having a drawer at the top and a cupboard below fitted with shelves for storing records; these shelves may rest on fillets screwed to the sides.

The right-hand portion, however, needs a little explanation. Here there is no drawer, although a false drawer front is framed between the end and the centre division (see B, Fig. 23). The board that carries the mechanism of the gramophone rests on fillets screwed to the sides (Fig. 24), the rear portion being secured to them with brass screws; but the front part is hinged so as to allow easy access to the motor for purposes of cleaning and lubrication. This front portion, carrying the motor, should be $\frac{3}{4}$ in. thick and should be clamped at the ends as in Fig. 29.

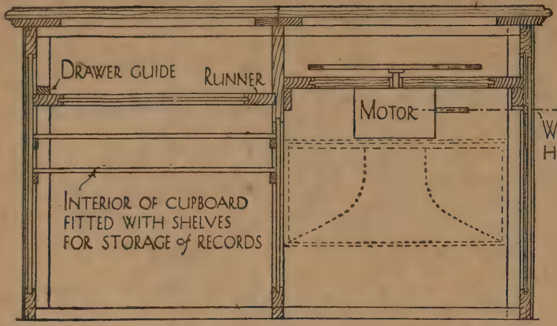
Wooden Horn.—The wooden horn calls for very careful setting out and nicety in working. The best method of tackling it will be to prepare the sides of it, to approximately the shape shown in the section, of $\frac{1}{2}$-in. material. Place them in their correct position with respect to one another, and connect the tops temporarily with a couple of thin battens and pins. A cardboard template should then be made of the bottom, the shape obtained cut from $\frac{1}{8}$-in. wood (the grain, of course, running in the direction which allows of easy bending), and carefully secured to the sides with glue and small brass screws. The top battens can then be removed and the top piece fitted in a similar fashion. The narrow end of the horn is secured by gluing round four strips C (Fig. 23) which are subsequently screwed into position, while the larger end of the horn is screwed to the edges of the filling boards D (Fig. 23). The open end of the horn may be screened either by a louvred front, as shown, or by means of a fretted panel.

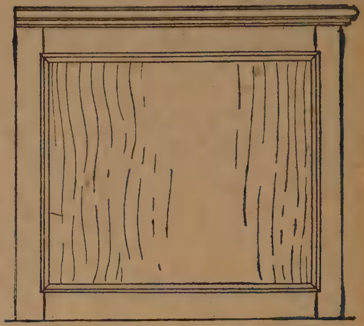


Figs. 22 and 23.—Front Elevation and Vertical Section of Gramophone Cabinet

The motor, brake and speed regulator will require careful fitting and adjustment.

The construction of the top will be seen from Fig. 23. The main top is $\frac{7}{8}$ in. thick, with a thumb moulding worked on the edges, thicknessed up all round with a





Figs. 24 and 25.—Longitudinal Section and End Elevation of Upper Carcase of Gramophone Cabinet

3-in. by $\frac{5}{8}$-in. strip, having a cyma recta or ogee worked on it. A detail of this is shown in Fig. 27. The top should be made $\frac{1}{4}$ in. longer than required, as it will need to be carefully sawn down the centre and the sawn edges planed and thicknessed up, as the left-hand portion is fixed, while the part covering the turntable is hinged.

Doors.—The doors may be made in two ways. The first is to construct a rebated framing, with centre rail and stile, beading in the panels, and gluing in the small triangular pieces to make the central octagonal-shaped boss. The small bolection moulding is then mitred round and glued and pinned in position. The second method, shown in the right of Fig. 30, is not so good, but is easier. Here the framework is prepared without a rebate, the latter being formed by the planting of the moulding. In each case the central boss is simply well glued and pinned.

Finishing the Oak to the "Jacobean" Colour.—Antique "Jacobean" colour finish may range from a light nut brown to a brown that is nearly black, a characteristic feature, in most cases, being a worn-off appearance on portions which it would appear were most likely to be subject to friction. This effect may be obtained by waiting until the stain is dry, wiping the work over with linseed oil and rubbing with a piece of wadding saturated with oil and dipped into medium-grade pumice powder. An effort is made with this rubber to rub the stain off again from those parts where the friction effect is desired. No grain-filler is required, as

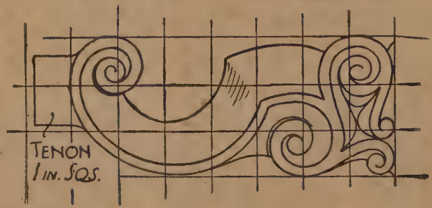


Fig. 26.—Detail of Carved Stretchers

Fig. 28.—Detail of Moulding to Table Part

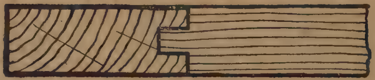


Fig. 29.—End Clamping of Motor Board

Fig. 27.—Detail of Moulding to Top

Fig. 30.—Section through the Doors

open grain improves the appearance. A "Jacobean" stain consists of 2 oz. vandyke crystals dissolved in $\frac{1}{2}$ pt. liquor ammonia, the mixture being then diluted with water so that it will give the desired colour by two applications. It may be necessary to add brown umber powder or yellow ochre to the stain, adding more ammonia to sharpen it up if already weakened with water. Oak is amenable to the darkening influence of bichromate of potash (1 oz. to 1 pt. water).

Motor-car and Motor-cycle Fault-finding Charts

In other chapters of this work information is given on overhauling motor-cars and motor-cycles. Below are presented charts which explain the sequence of operations in determining the cause of trouble occurring at starting or during running.

Engine Stops: General Causes

- No petrol at carburettor jet
  - No petrol in tank
  - Choked jet
  - Petrol tap closed
  - Choked petrol pipe
  - Float needle sticking
  - No air vent in tank
- Spark at plug points
  - Compression good
    - Carburettor in order
      - Overheating
      - Tappet adjustment
      - Lubrication
      - Broken valve spring
      - Controls out of order
      - Air leak
      - Broken valve cotter
      - Broken valve
    - Carburettor faulty
      - Choked jet
      - Carburettor flooding
      - Float needle sticking
      - Punctured float
  - Compression faulty
    - Burnt valve
    - Broken valve cotter
    - Broken valve spring
    - Piston rings carbonised up
    - Broken piston rings
    - Valve binding in guide
    - Piston ring slots in line
    - Broken piston, gudgeon pin, connecting rod or crank shaft

Engine Stops: Ignition Cause

- No spark at plug points
  - No spark at magneto
    - Dirty contact points
    - Short circuit owing to wet or mud
    - Magneto contact-breaker sticking
    - Contact points loose
    - Broken carbon brushes
    - Contact-breaker key sheared
    - Contact-breaker spring broken
    - Insulation breakdown
    - Faulty condenser
  - Spark at magneto
    - Sooted plug
    - Magneto timing slipped
    - High-tension cable detached
    - Broken plug

- Engine Will Not Start
  - No petrol at carburettor jet
    - No petrol in tank
    - Petrol tap closed
    - Choked petrol pipe
    - Air lock in petrol pipe
    - Choked jet
    - Float needle sticking
    - No air vent in tank
  - Carburettor floods when float is depressed
    - Spark at plug points
      - Carburettor levers incorrectly set
      - Throttle closed
      - Controls not working
      - Air leak
      - Spark too weak
      - Timing incorrect
      - Magneto timing slipped
    - No spark at plug points
      - Spark at terminal
        - Sooted plug
        - Faulty plug
        - Spark too weak
      - No spark at terminal
        - Dirty contact points
        - Magneto contact-breaker sticking
        - High-tension cable detached
        - Short-circuit owing to wet or mud
        - Contact points loose
        - Broken carbon brushes
        - Contact-breaker key sheared
        - Failure in magneto insulation

- Engine Runs Badly
  - Lacks power
    - Constantly
      - Compression poor
      - Valve clearance wrong
      - Partial stoppage of petrol supply
      - Carbon deposit
      - Incorrect mixture
      - Silencer choked
      - Timing incorrect
      - Worn cams
      - Gear too high
      - Weak valve springs
    - At intervals
      - Temp. stoppage of petrol supply
      - Loose control cables
      - Valve tight in guide
  - Engine knocks
    - Overheating
    - Too much air
    - Ignition too far advanced
    - Pre-ignition
  - Misses fire
    - Spark irregular
      - Sooted plug
      - Water in petrol
      - Magneto contact-breaker sticking
      - Dirty contact points
    - Spark regular
      - Improper petrol supply
      - Mixture too weak
      - Occasional short circuit

High-class Brushes and How to Make Them

For high-class hand-made brushes there is always a ready sale and constant need. A great deal can be done without machinery, and the requisites for the work are not difficult to obtain, neither are they expensive.

The majority of household brushes may be roughly divided into two classes—those in which the material is wired or string-stitched into the wooden part, and are termed "drawn" brushes, and those in which the knots of bristle or fibre are cemented in. It is proposed to describe only the first of these classes as the making of the second class of brush is a factory job that will scarcely interest the amateur mechanic.

Materials.—The materials used in the making comprise hog's bristles, horsehair, goat's hair, bass and coco-nut fibre. Others, vegetable fibres, esparto grass, etc., are occasionally used for inferior productions.

For the "stocks" of the brushes the hard woods used are mainly sycamore, beech, elm, birch, chestnut, oak and mahogany, ash being a favourite wood for brush handles.

Bristles, which form the chief material used in the manufacture of brushes, are the stiff hairs growing on the back of the hog, and wild boar. The material is imported from France, Belgium and Russia, the quality depending on the length, elasticity, colour and straightness of the hairs, the long, light-coloured variety being the most expensive. When received from the dealers, the material is sorted to separate the longer and better hairs from the inferior. Bristles required white are bleached in a weak solution of sulphurous acid.

Making a Flat Clothes-brush.—Four common types of "drawn" brushes are illustrated by Figs. 1 to 4. Taking the flat clothes-brush (Fig. 2) as a typical sample of the class of drawn brushes, the process of manufacture, which is the same in all the four examples given, will be described.

The Backs.—Of the wood employed for the backs of these brushes, beech and mahogany are popular varieties, the latter having the great advantage that it polishes excellently; but cheaper woods are frequently used, and finished by staining, polishing, etc.

The four types shown by Figs. 1 to 4 are made in such a large variety of sizes and shapes that it will be unnecessary to give actual dimensions in each case. The wooden backs consist of two parts: the main portion in which the hairs are planted, and a thin portion glued over the back, the necessity for which will be seen when the process of manufacture has been described.

For a flat clothes-brush of useful size, the blanks would measure about 3 in. by 9 in., being cut from material $\frac{3}{8}$ in. to $\frac{1}{2}$ in. thick. It will be found best first to make a zinc template carefully cut to the exact shape of the back of the brush, the method of setting out with compasses being made clear by Fig. 5. This done,

the zinc template can be employed to mark out the shapes on the wood as economically as possible. The best method, then, will be to saw out the plain rectangular shapes with the hand-saw, and then cut the curved ends afterwards, finishing up with plane and spokeshave or rasp. From Fig. 6 it will be seen that at each end from the place where the curve starts, a little of the wood is planed away to give a rounded contour at the top as shown. This is not always done, but it will be found to improve the appearance. After a little practice it will be found that these blanks can be turned out very quickly, and a worker will find it convenient to prepare a stock of a hundred or so before proceeding.

The next consideration is the drilling; but before this can be put in hand, the material that is to hold the "knots" of bristle in their places has to be decided on. This may be either string or thin iron-wire. If string or twine is used, it must be very strong, or it will break in the working. Thin iron-wire is mostly generally used. The processes of stringing and wiring are similar, but there are slight differences, which will be enumerated.

Grooving the Backs.—In the system in which the knots of bristle are secured into the wood back with string, the first process is the grooving. For this will be required a small gouge of the form shown by Fig. 7. With this, following the contour of the brush, a channel is cut about $\frac{5}{16}$ in. from the edge in the case of a brush of the dimensions given. The cut should be as regular as possible, though absolute evenness is not essential; it does not require to be deep. A similar incision is then made all the way round inside the first, at a distance of about $\frac{1}{16}$ in. from it, the process being rendered clear by Fig. 8, two slight cuts down the middle completing the back, which is then ready for drilling.

Fig. 1.—Handled Clothes-brush

Fig. 2. — Flat Clothes-brush

Fig. 5.—Setting out Back

Fig. 3.—Handled Hair-brush

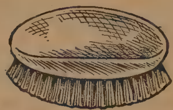


Fig. 4.—"Military" Hair-brush

Fig. 6.—Side of Brush Back

Fig. 7.—Gouge for Grooving Brush Backs

Drilling the Backs.—In the trade the drilling is always done with a lathe, as by this means it can be got over very quickly. It will be found to pay any small manufacturer who is taking up the work at all seriously to invest in one if he can, as a great deal of labour will be saved. The type of "bit" invariably employed is the "shell" bit. It is fixed into a device with a square-shaped slot cut in it, and is held in the lathe chuck. The bit for the present purpose only requires to be a small

one, about $\frac{1}{8}$ in. being the size. Fig. 9 gives some idea of the spacing of the holes, which are all drilled at the bottom of the grooves at about a distance of $\frac{3}{8}$ in. apart. The back is drilled without any sort of guide, it being pressed by the operator against the revolving drill. The grooves will be found sufficient guide as to the disposition of the holes, which are made right through the wood back, Fig. 9 showing the drilling completed.

With a lathe such as described, after a little practice, the worker will find that he can get through the work very quickly indeed, especially if he can fit up a small power plant to work the lathe. For brush-making on a very small scale, a hand-drill may be used ; but it will be found a rather more lengthy process to accomplish the drilling by this means.

Tying-in the Knots of Bristle.—The bristle or hair for a clothes-brush should be about 2 in. long, which will allow ample for clipping. It should be cut and neatly piled ready to hand during the operation of stringing the "knots" into place, the brush-back during the operation being firmly fixed in the jaws of a vice. The position marked A in Fig. 10 will be found a convenient place to start at, though there is no hard-and-fast rule about the matter. Cut about a 3-ft. length of strong string or wire, pass an end through a hole, then pick up in the fingers a bundle of bristle that is estimated tightly to fill the hole when doubled, and draw the string round it as indicated in Fig. 13, taking the end back through the hole that it was first inserted into. Then by exerting a good pull on the two strands with the left hand or with a pair of flat pliers, draw the double bundle of bristle into the hole (see Fig. 14). Pull well in, then leave the short end of the wire and pass the other end through the hole, as at B (Fig. 10). Pull tight, then insert back again through the same hole, but not pulling tight, until a similar bundle of bristle has been inserted in the loop formed, and pulled through in the same manner as the first, the operation being rendered quite clear by Fig. 11.

The next move is a rather peculiar one. The working end of the string is carried back to the hole indicated by C in Figs. 10 and 11, a knot of bristle being inserted in the loop formed after the string has been put through the hole and back again. Thus the work is continued right round the brush until the hole D (Fig. 10) is reached, when the string is carried to a hole in the inner grooving as shown, by making a notch with a knife so that the wire or string will not stick up above the


Fig. 8.—Grooved Brush Back

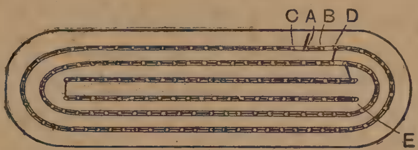


Fig. 10.—Grooved, Drilled and Stitched Back

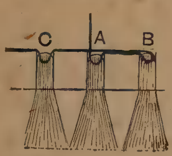


Fig. 11. — Side View of Knots

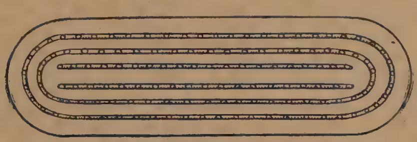


Fig 9.—Drilled and Grooved Back

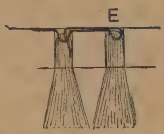


Fig. 12. — End of Stringing

surface of the wood, the purpose of the grooves being to form a hollow to sink it in, so that a level surface is left for gluing on a thin backing to the brush.

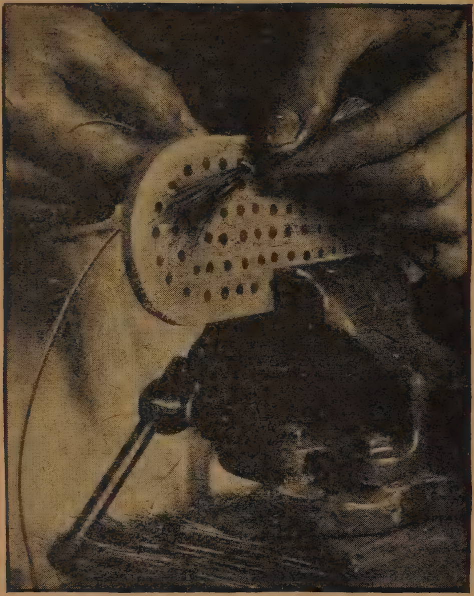


Fig. 13.—Starting Stringing of Brush

Some little judgment is, of course, necessary in order to select just the right amount of bristle that will tightly fill each hole when doubled. As all the holes are of equal size, when once the correct amount has been gauged, after one has had a little practice in the work, it will become an instinct in picking just the right quantity. It is most essential in the making of a brush that each hole is tightly packed, and the bristle well drawn into the holes, otherwise the knots would soon loosen and the bristle work out of place, the result being a badly wearing brush.

Fig. 10 gives a back view showing the stitching of the complete brush, the direction of the work being clearly indicated, the work starting at A and finishing at E, the end of the string at this point being cut off short, then taken back and pushed into the previous hole, as shown by Fig. 12.

Wire-stitching.—In the case of brushes stitched with wire, the grooving of the back is generally omitted, especially in cheap productions in which the backs are of wood soft enough for the wire to be impressed into it when the back is glued on, so that the veneered covering will lie perfectly flat. In starting to wire in the knots of bristle, it is often the practice to make a sort of slip-knot at the beginning of the wire, and this is slipped round the bundle of bristle and pulled tight ready for drawing through. Wire, it may be mentioned, is almost invariably employed for making the smaller brushes. It is stronger than string, and less liable to break during the working.

Covering the Brush Backs.—The material employed for covering the backs of these brushes should preferably be of the same variety as the brush back itself, though it is not always so in the case of the cheap lines. Veneer woods are frequently used, not more than $\frac{1}{16}$ in. thick. It is cut a little larger than the back,

Fig. 14.—Drawing Knot into Hole

which is given a thin coating of hot glue and the covering applied. The brush back is then gripped in the vice, so that the glued piece can be pressed down hard

on it to squeeze out all glue that is superfluous, the back being then secured on with small brass tacks inserted at intervals of 1 in. or so. Sometimes the tacks are omitted, the veneer being merely glued to the back, and then held in place with a caul until the glue has hardened; but such backs are always likely to "spring" at the ends and split off in use. The former method will therefore be found the quicker and better one.

Finally, the bristles are trimmed level with shears, the back and sides being then glasspapered and prepared for the final process of staining, japanning or polishing.

Fixing Perambulator Tyres

Wired-on Tyres.—In the ordinary wired-on tyres of perambulators, bassinettes, mail-carts, etc., something like $\frac{3}{4}$ in. extra must be allowed to every foot of tyre, so that although the tyre is stretched on the wheel, there is more rubber than is sufficient to fill the bed of the rim, and the tyre is always in compression. The join will keep close and prevent wet reaching the wire, and any cuts will tend to close up. Wiring-on seems a formidable task, but once the following method is mastered, the job becomes simple.

All tyres of the above kind are made in various diameters to fit the rim, $\frac{3}{8}$ in., $\frac{1}{2}$ in., $\frac{9}{16}$ in., and $\frac{5}{8}$ in. being the usual sizes, and care must be taken to get the right size for the rim, which is half-round. The wired-on tyring is sold in coils of 60 ft., and the wire in 100-ft. coils.

Tools Necessary.—The tools required are: two spoke grips of the "King Dick" pattern (Fig. 1); a stout bench or leg vice, which must be strongly secured, as it has to stand the strain of one's whole strength when compressing the rubber tyring; a piece of round steel rod about $\frac{3}{8}$ in. or $\frac{1}{2}$ in. in diameter, flattened at one end to fix in the vice (a punch for corrugated iron is the best thing; it has a hexagonal handle, which will neither bend nor snap off); a fretworker's clamp (Fig. 2); a piece of quartering about 1 in. by 1 in., 6 ft. or 7 ft. long, for a gauge rod; and some french chalk. Use good quality tyring and crimped wire.

Wiring-on a Tyre.—Remove the old tyre, and clear out the rim if cement has been used. Drive a nail into the gauge rod about 6 in. from one end, leaving about 1 in. projecting. Make a mark on the rim with a file, and place the wheel on the gauge rod, with the mark opposite the nail. Have another nail and a hammer ready. Roll the wheel down the rod until the mark again comes down to the rod, then drive the nail lightly in at the mark. This gives the exact circumference of the rim, so care must be taken to keep the rim running in a straight line, and not to let it slip. All rims are not quite the same size in circumference, although supposed to be standardised, so check each wheel on the gauge, as even $\frac{1}{4}$ in. will make all the difference in the correct fit.

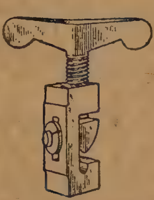


Fig. 1.—Spoke Grip

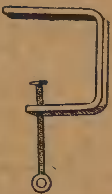


Fig. 2.—Fretworker's Clamp

Take the crimped wire and unwrap sufficient to overlap the nails by about 4 in. at each end. In doing so do not cut the wires that hold the coil together, but pull it through, leaving the binding wires equally spaced, or the remaining wire will get in a tangle. With a round file make a mark on the wire about 4 in. from one end; not a notch, or it will be liable to snap off.

Place this opposite one nail on the gauge rod, hold it there with the clamp, pull the wire straight until it comes opposite the other nail, and make a mark as before. Cut the wire 4 in. from this mark. Then take the wire, place the two marks together and lock the crimping as at B (Fig. 3), so as to form a wire circle (Fig. 3). This should just go over the rim, being exactly the same diameter. If it is too big the tyre will not be a tight fit ; if it is too small the tyre will not go on without damage. A little practice will make this clear and do away with this necessary trial.

Now take the tyring, place it in the rim, using the right size, and cut it off, allowing 2 in. to 3 in. extra. This is to make up for compression and ensure a tight join. The ends must be perfectly square. Now

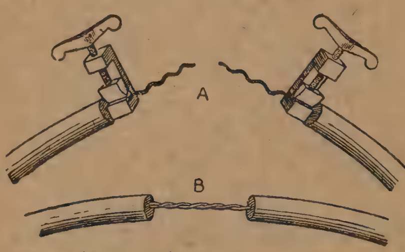


Fig. 3.—Fixing Wired Tyres

introduce a little french chalk into the hole in the tyre, either by putting a little in at a time by the aid of a knife, or the quicker way is to put one end of the tyring into the packet of french chalk, and suck it through cautiously. Be careful not to get a mouthful of the chalk.

Then unlock the wire and thread it through the tyring, which, if sufficient chalk has been used and the wire has not been bent, will be easily done. Fix one of the spoke grips on the wire as at A (Fig. 3), not too tightly so as to damage the wire, but sufficient to hold. The other end must be tightly gripped in the vice, using about 1 in. only. Starting at the end away from the vice, gently haul on the tyring as hauling on a rope, going hand over hand, and the tyring will be gradually compressed, until at the vice end there will be about 9 in. of wire showing, with the mark 4 in. or 5 in. from the end of the tyring. Holding on with one hand, fix the other spoke grip on the wire close up to the rubber. Screw up firmly this time, as it will have to bear a much greater strain. Now reverse the wire, placing the opposite end in the vice. Haul on the rubber as before, but now with greater force. It may be mentioned that $\frac{3}{8}$-in. tyring will not stand too much compressing. When the rubber is a few inches past the file mark, refix the spoke grip close to the rubber, and take the wire out of the vice. The tyring is now compressed on the wire between two spoke grips, with the file marks showing a few inches beyond the grips A (Fig. 3). Place these marks together and lock the crimping, making a joint about 4 in. long (B, Fig. 3). Cut the superfluous wire off with wire-cutters, and turn the sharp ends inwards, or they will cut through the tyre. In making the joint do not use pliers, or the crimping will be pulled out of shape. This will show the necessity of keeping the wire free from damage. If the crimping does not just tally with the file marks, take the nearest crimp, but err rather on the tight side.

Now remove the grips, and the rubber will spring back, entirely covering the wire joint and scarcely showing a join, which may, if necessary, be smoothed down with a file. Fix the $\frac{3}{8}$-in. rod in the vice, and place the wheel on it. Put on the tyre with the join in the rim first, and stretch the tyre until it jumps into its place. An extra pair of hands will be found useful. If the wire is too tight the tyring will probably be cut, and it will be necessary to start all over again, using as much of the rubber as is undamaged, making up with new. If the tyre is too slack pull back the rubber, and get someone to cut the wire. If it is necessary to make a second attempt use fresh wire.

Cementing-on a Tyre.—The cement used for fixing tyres is a variety of marine glue. The method of applying the cement is as follows : Connect a bunsen burner or flat gas stove to the gas-pipe by a sufficiently long pipe to allow the burner to be placed on the floor ; or, if on a bench, place below the burner a piece of sheet-iron. Through the hub of the wheel put

an iron rod (a poker will do), and rest it on supports on each side of the burner, so that the rim of the wheel is held about 2 in. above the flame. Now heat the rim by means of the burner, and, while the rim is hot, place in the groove a little of the cement, moving the wheel around until the whole of the groove is thinly coated; then give the wheel a slow turn all round to get the rim warm and the material soft, and spring on the rubber tyre. Press it well into position, and see that the cement adheres to the tyre when it is cold.

Failing the gas burner, use a hot iron, running it round the groove to melt the cement before putting on the tyre.

A method that an inexperienced worker would find of service, although it would occupy more time, is to put the tyre on the cleaned wheel before applying any cement. Tie it in position in eight places equally spaced. Then spring off one section of the tyre, melt the cement over the flame from a gas-ring, and run it in the portion of the rim exposed. This soon solidifies, so that when the tyre is put back again no adhesion takes place. When all the sections have been treated in the same way, the string is removed and the cement remelted by holding a portion of the rim about 1 in. above a medium flame of the gas-ring. All the rim is treated in this manner, the wheel being revolved horizontally, so that when the wheel becomes cold, the tyre and rim will be firmly stuck together.

Care should be taken not to burn the tyre, but only to heat the rim so that the cement melts and runs into the corrugations on the underside of the tyre. It is better to use too much cement rather than not enough. When the tyre is pressed in position, any superfluous cement is squeezed out at the sides and can easily be removed.

Boot and Shoe Polishes, Blackings, etc.

A GOOD shoe polish should preserve the leather, render it soft and flexible, and impart a gloss with slight polishing which is not dimmed by exposure to ordinary atmospheric moisture. The treatment of shoes with polish is too well known to need description here, but it should be remembered that the polish must be applied only in a thin layer, and not heaped on the leather. The almost universally employed pigment for black shoe polishes is bone-black, or animal charcoal, which must have been treated for the removal of lime phosphate and acid. Bone-black in an exceedingly fine state of division is known as ivory black. Lampblack and Frankfort black are also used as pigments, mixed with substances capable of imparting the necessary gloss to the final product.

Expensive polishes possessing a beautiful colour are made by the addition of a small percentage of freshly precipitated prussian blue (ferric ferro-cyanide) to the bone-black, which affords a bluish-black shade of fine metallic lustre.

All boot polishes contain an agglutinant or adhesive ingredient, which fixes the pigment on the leather and imparts a gloss when brushed. Glycerine alone may be used for this purpose; but a mixture comprising 2 parts of molasses and 1 part of glycerine is preferable.

A third constituent is necessary in blacking, especially in such mixtures as do not contain glycerine. This is a preservative which ensures the leather keeping soft and flexible; usually it consists of a non-drying fat or fatty oil, such as olive oil, sesame oil, lard, fish oil, etc. Olive oil is, of course, to be preferred, but owing to its high price is usually substituted by the cheaper sesame oil. Lard is expensive and rapidly becomes rancid,

and fish oil, unless in a highly purified state, has an objectionable smell. The ratio of bone-black to these oils usually employed is as 1 to 10 by weight. Too great a proportion of oil renders the polish incapable of producing a gloss, besides causing dust to adhere firmly to the shoe.

A very small proportion of oil only is necessary in polishes containing glycerine, since the latter material suffices to keep the leather soft and flexible.

The procedure generally pursued is first very finely to pulverise the pigment, add to it any other mineral colourant, such as prussian blue, incorporate with the agglutinant, then the oil, and finally to mix with sufficient water, beer, or vinegar in order to reduce the polish to the required constituency. Great care should be taken to avoid contact of naked flames with any of the preparations, as many of them are highly inflammable.

Expensive but Efficient Polishes.—(1) Melt 90 parts by weight of beeswax, 30 parts of spermaceti, 350 parts of oil of turpentine, and 20 parts of asphaltum lacquer. Stir in this order, 10 parts of borax, 20 parts of bone-black, 10 parts of prussian blue, and 5 parts of nitrobenzene.

(2) Dissolve 150 parts of beeswax and 15 parts of tallow in a boiling mixture of 200 parts of linseed oil, 20 parts of litharge and 100 parts of molasses. Heat to a temperature of from 230° to 248° F. to remove all moisture, and add 100 parts of lampblack. When cold dilute with 280 parts of linseed oil, and mix with a solution of 5 parts of gum-lac and 2 parts of aniline violet in 25 parts of alcohol.

(3) Incorporate thoroughly 6 parts of fine bone-black, 28 parts of syrup, 4 parts of sugar, 3 parts of train oil, and 1 part of dilute sulphuric acid. Allow the mixture to stand for eight hours, and add, with constant stirring, 4 parts of decoction (or boiled extract) of tan, 18 parts of bone-black, and 3 parts of sulphuric acid, finally pouring the polish into boxes for the purpose of setting.

(4) Boil 1 part of extract of logwood and 30 parts of gall-nuts coarsely powdered with 25 parts of their combined weight of strong vinegar. Filter the fluid, and after adding 8 parts of green vitriol to the filtrate, allow to settle for twenty-four hours. Next decant the clear liquid, and mix, whilst stirring, with 8 parts of gum, 100 parts of sugar and 80 parts of syrup. Strain the concoction, and add 50 parts of spirits of wine, 40 parts of shellac solution, and 40 parts of pulverised indigo.

A blacking resembling that identified with a certain well-known name is obtained by mixing ground animal charcoal, sperm oil, raw sugar or treacle, and a small proportion of vinegar. Dilute sulphuric acid is then added to the mass until frothing ceases, and the product is thinned by the addition of vinegar.

Liquid Blacking.—This can be prepared from 120 parts of ivory black, 90 parts of brown sugar, 15 parts of olive oil, and 500 parts of stale beer. The ivory black, sugar, and olive oil are mixed into a smooth paste and beer added with constant stirring.

A German recipe for a similar preparation is as follows: 25 parts of Marseilles soap are dissolved in 375 parts of warm spirit of 25 per cent. purity, and 40 parts of glycerol added. This is shaken and added to a solution of 200 parts of shellac dissolved in 1,000 parts of spirit of 95 per cent. purity, and 5 parts of nigrosine in 125 parts of spirit added. The mixture is well shaken in a closed bottle or vessel, and left for a fortnight before use.

Liquid Polish.—Mix 4 oz. of asphaltum, 8 fluid oz. of turpentine, 3 fluid oz. of gold-size, ¼ oz. of nigrosine, and 3 fluid oz. of linseed oil. The mixture is heated until uniform, and thinned down to the desired constituency with oil of turpentine.

Bryant and James's India-rubber Blacking.—Thoroughly grind together 18 oz. of very fine shreds of india-rubber, 9 lb. of hot rapeseed oil, 60 lb. of finely powdered bone-black, 45 lb. of treacle, 1 lb. of gum arabic previously dissolved in 20 gallons of vinegar. The whole is placed in a wooden vessel, and 12 lb. of sulphuric acid added in small quantities at a time and stirred for half an hour daily for fourteen days, 3 lb. of finely-powdered gum arabic added, and the stir-

ring continued for a further fourteen days. If required in the paste form, only 12 gallons of vinegar need be added, and six or seven days' stirring is sufficient.

Cordova Blacking.—This is especially recommended for blacking shoes, boots, harness, etc., since it contains neither hydrochloric nor sulphuric acid, and hence is less deleterious to the leather than blackings containing these acids. Mix vinegar, 1,500 parts, beer 500 parts, good cabinet-makers' glue 250 parts, sumac 60 parts, isinglass 4 parts, indigo blue 2 parts, and allow the whole to boil gently for half an hour. Strain, after cooling, and apply to the leather with a sponge.

Gutta-percha Blacking.—The presence of gutta-percha in blacking causes the leather, after repeated treatment, to become practically waterproof. The blacking is prepared as follows: (*a*) Dissolve 20 parts of gum arabic in 1,000 parts of water. Pour 50 parts of olive oil over 20 parts of gutta-percha cut in pieces, and melt, with repeated stirring, into a uniform paste, and then pour into the dissolved gum arabic; (*b*) Mix intimately 200 parts of bone-black, 400 parts of lamp-black, and 1,500 parts of molasses. Finally melt mixtures (*a*) and (*b*) together.

French Paste for Patent Leather.—To preserve the gloss of patent leather the following preparation is employed: Melt some pure wax over a water-bath, place on a moderately hot coal fire, add first some olive oil, then some lard, and mix intimately by stirring. Next add a little oil of turpentine, and finally a few drops of oil of lavender. The resulting paste is filled into boxes, where, on congealing, it will acquire the necessary constituency. Apply in small quantities to the boots or shoes and rub with a linen rag, which ensures the leather keeping soft; it imparts a fine gloss.

Dressing for Kid Shoes.—2 oz. of gum shellac, 1 oz. of aqueous ammonia, 8 oz. of water, and sufficient aniline black to produce the required colour. The first two ingredients are heated almost to boiling, and water is added to make up the volume to 16 oz.

Hardeg's Leather Ointments.—(1) Melt and mix yellow wax, oil of turpentine, olive oil, castor oil, each 25 parts, and purified boiled linseed oil 50 parts; then add, with constant stirring, $27\frac{1}{2}$ parts of pure wood tar; (2) Melt and mix yellow wax, oil of turpentine, and castor oil, each $12\frac{1}{2}$ parts, linseed oil 125 parts, and tar $3\frac{1}{2}$ parts.

Dressing for Boots as Used by the Normandy Fishermen.—Mix 50 parts of good linseed oil, 35 parts of spermaceti, 5 parts of yellow wax, and $3\frac{1}{2}$ parts each of pitch and oil of turpentine. Melt the whole in an earthenware pot over a moderate fire, taking care to prevent the mixture from igniting. The ointment is rubbed into the leather, and then dried by exposure to heat.

Modern-style Boot-Polishing Paste.—Wax polishes have proved advantages over the old-fashioned blackings. *Brown*: Dissolve 2 oz. of beeswax by heating in 3 oz. of turpentine and stir in 5 to 10 grains of nankin brown strain. This recipe is for a basis that may be varied in several ways; for instance, 1 oz. of beeswax and 1 oz. of ceresine may be used instead of 2 oz. beeswax. If this proves too "short," add $\frac{1}{2}$ oz. of palm oil. Again, instead of turpentine, 3 oz. of turpentine substitute, or 2 oz. of substitute and 1 oz. of turpentine could be used. *Black*: Use the same basis as above, omit the nankin brown stain, and, while hot, stir in 2 dr. of best nigrosine, which must be the kind known as "spirit soluble." There are several shades of aniline black, and as some are not sufficiently "black," a few grains of a dark aniline blue, which must be spirit soluble, will be found an improvement. This is a matter for experiment.

Simple Methods of Charging Accumulators

In an earlier chapter the construction and working of an accumulator are illustrated and described. The accumulator (or storage battery or, simply, "cell") is a very useful appliance, but it is entirely dependent upon correct charging and careful discharging, and this chapter has been especially written to meet the needs of people who find difficulty in understanding the rules that govern the matter.

Kind of Electric Current. — The charging of accumulators from electric mains presents some problems to the amateur. In the first place an accumulator can only be charged from the public supply providing that the current is what is termed direct or continuous, unless special rectifying apparatus is used. The two kinds of current are "direct" and "alternating," and if the nature of the supply is not known it may easily be learned upon inquiry from the supply company. Briefly it may be stated that direct or continuous current flows in one direction only, whereas alternating current first flows in one direction and then in the other (or, as the term implies, alternates), the alternations usually being at the rate of fifty per second.

It is proposed to deal in this chapter with direct current only, for, as before stated, charging with alternating current necessitates the use of special rectifying apparatus not likely to be in the possession of most amateurs.

"Capacity" of an Accumulator.— An important consideration in accumulator charging is the capacity of the accumulator to be charged, as upon this depends the amount of current that can be allowed to pass into it. The capacity of an accumulator depends upon the size and number of the plates; usually it is stated on the case, but may be easily calculated. Before entering into this matter it will be as well to understand how electricity is measured. The pressure of electricity is measured in volts and the amount of flow in amperes. It is the volts that force the amperes through any particular circuit, the number of amperes flowing depending upon the pressure (volts) that creates the flow, and the resistance that the circuit offers to the flow. Now the resistance of an accumulator is very small, and if a voltage is applied that is greatly in excess of the accumulator voltage, the resultant rush of current would be very great, so great in fact that the plates would be disintegrated. The actual amount of current that can safely be allowed to pass depends upon the total area of the plates, or, in other words, upon the capacity, and this is reckoned in ampere-hours. For the sake of illustration, the rating of a cell may be, say, 30 ampere-hours, which means that, when fully charged, it is capable of discharging a current of one ampere for thirty hours, or equally two amperes for fifteen hours; the number

of amperes multiplied by the period of discharge in hours must, in this case, equal 30; in a 60-ampere-hour accumulator, 60, and so on.

It is obvious that the more plates there are of each kind (negative and

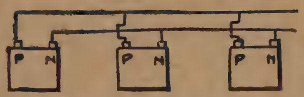


Fig. 1.—Accumulators Connected in Parallel

positive) coupled together, the greater will be the capacity of the cell and, further, that these plates may not necessarily be in one cell. If the plates of one of the accumulators shown in Fig. 1 are assumed to have a capacity of thirty amperes, then the capacity would be trebled by adding two similar cells with the plates connected in parallel—that is, all the positives of one cell connected to all the positives of the other, and all the negatives similarly connected, as illustrated.

Alternatively to the cells being connected in the manner described above, if the positives of one cell be connected to the negatives of the other as shown by Fig. 2, then instead of the capacity being trebled, the voltage would be trebled, the capacity remaining the same as for one cell. This is termed the "series" connection as distinct from the "parallel" before described. If the capacity is not stated on the case, it may be reckoned as

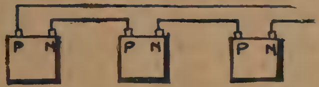


Fig. 2.—Accumulators Connected in Series

ten ampere-hours per square foot of positive surface, reckoning both sides of the plates, but if the plates are series-connected, only those of one cell should be reckoned. Some confusion is liable to occur with regard to this matter, but a simple explanation will make it clear. All accumulators are built up of a number of cells, each representing a pressure of about two volts, and each cell contains its own electrolyte or liquid; thus a 4-volt accumulator consists of two such cells and a 6-volt of three, and so on, though they may be all fastened together with the outward appearance of being one cell. It is the positive-plate area of one of these divisions only that must be calculated if series connected.

Adapting the Charging Current.—The charging rate of an accumulator should never exceed one-eighth to one-tenth of its total capacity; this fact causes complications, because current obtained by connecting a cell to a public

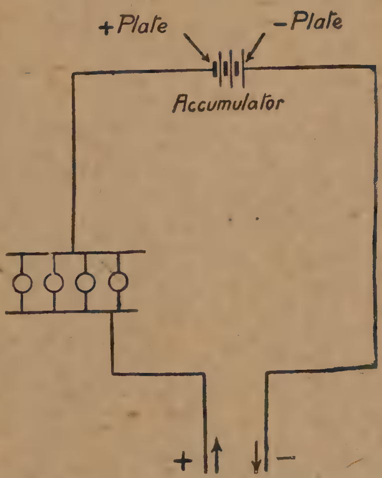


Fig. 3.—Simple Accumulator-charging Circuit with Lamps as a Resistance

main would be too ample and at too great a pressure for the purpose. In order to check the amount of current that can flow into an accumulator when it is connected to the mains, it is necessary, therefore, to interpose a resistance, and the most simple form of resistance for this purpose is a lamp or lamps, the circuit being as shown in Fig. 3. The current that will pass through one lamp is very small, and except for an accumulator of a very small size would necessitate a very long charging period. In order to increase the charging rate it is necessary

to add more lamps and arrange them in parallel as shown, this allowing of more current passing *pro rata*.

Lamps of different candle-powers pass different amounts of current—the higher

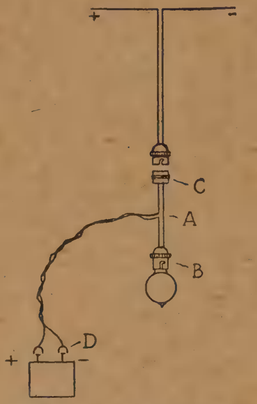


Fig. 4.—Method of Charging Accumulators from Electric-light Pendant

the candle-power the greater the current. Another matter that affects the amount of current passing is the class of lamp used, whether carbon-filament, or metal-filament, the former passing rather more than double the current passed by the latter. The current any particular lamp will pass may be found by the application of the following rule: Multiply the candle-power by $3\frac{1}{2}$ for carbon-filament lamps, or by $1\frac{1}{4}$ for metal-filaments, and divide the result by the voltage of the mains. The answer will be in amperes or fractions of an ampere. A few examples are given below:

					amperes
one 8-candle-power	carbon-filament	lamp	takes or passes		0·127
one 16	,,	,,	,,		0·254
one 24	,,	,,	,,		0·381
one 32	,,	,,	,,		0·508
one 40	metal-filament	,,	,,		0·227
one 60	,,	,,	,,		0·34

All the above are 220-volt lamps. For 110-volt lamps the amperes passed will be twice as much.

As an instance, suppose that it is desired to charge a 4-volt 30 ampere-hour accumulator. The charging rate (one-tenth of the capacity) would be $\frac{30}{10} = 3$ amperes. As a 220-volt 16 candle-power carbon-filament lamp *passes* 0·254 ampere it would be necessary to use twelve of these connected in parallel. If metal-filament lamps were used, thirteen 40 candle-power lamps would be required to pass nearly the same current. A smaller number of lamps could of course be used, but in that case the charging time would be proportionately greater.

Supposing now that it is desired to charge a second accumulator of the same size at the same time; if the two were connected in parallel the charging rate could be doubled, but the cost for current would be double that entailed if the cells were connected in series.

The Proper Connections.—Whatever charging system is adopted, as described later, the first matter is to determine the polarity of the mains, as it is necessary that the positive wire should be connected to the positive of the accumulator—that is, the terminal painted red, which is connected to the series of chocolate-coloured plates. The polarity may be found by placing the wires a little distance apart in a glass of acidulated water (vinegar and water will answer), when it will be found that bubbles freely arise from one of the wires. This is the negative and should be connected to the terminal painted black. In testing the wires for polarity, care must be taken that the wires do not actually

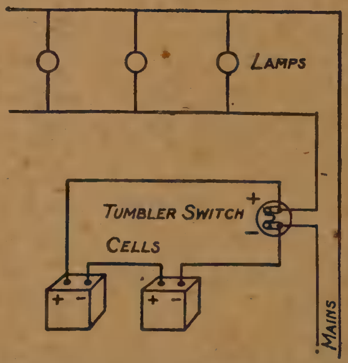


Fig. 5.—Method of Charging Accumulators from Electric-light Switch

come into contact with each other, and it is advisable that the current should pass through a resistance.

Another method of determining the

polarity is by the use of pole-finding paper, obtainable from any electrical dealers. The paper should be moistened, and the two wires should be placed on it about half an inch apart, and the current switched on. A red spot will be produced on the paper at the negative wire.

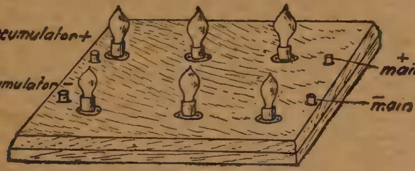


Fig. 6.—A Lamp Resistance Board

Regarding the actual charging arrangements, probably the simplest is that in which *one* wire of a pendant is cut, and a wire connected to each cut end, and the accumulator connected thereon. A method that obviates the cutting of the wire is shown by Fig. 4. Instead of the lamp being in the pendant socket, an adaptor C is fitted into this, wired to the lamp socket B, as shown at A, the two free ends of wire being left for connection to the accumulator D.

Another simple system needing very little preparation is to make the accumulator act as the bridge of the switch, as shown in Fig. 5. A wire is connected to each of the switch terminals, the polarity determined, and the accumulator connected to them, the switch of course remaining in the open position.

Such arrangements as the foregoing possess the advantage that the accumulator can be charged whilst ordinary use is being made of the light, the difference in the illumination provided by the lamp being so slight as to be hardly appreciable.

The current with the above arrangements is limited, of course, by the number of lamps on the pendant, and this is usually one, two or three. A better system is to mount some lamps on a board by providing sockets as shown in Fig. 6. The number of lamps may range from two to six or even more, as may be desired · with a larger number it is always possible to remove lamps in order to cut the current down, as the connections are not affected.

The connections for this type of charging board are shown in Fig. 7. Two terminals for the mains are provided at one end, and two more terminals at the other, the accumulator being connected to the two latter.

Connection can be conveniently made from the mains by means of an adaptor, but if more than six lamps are used and connection is made to an ordinary pendant the size of the fuse wire for that particular pendant should be increased or the fuse may "blow," owing to the fact that it will be called on to pass a heavier current than it is intended for.

The Actual Charging.—A new accumulator should be filled with a mixture of the best brimstone sulphuric acid and water of a specific gravity of 1·200 (5 parts of acid to 21 of water), the level of the liquid being a quarter of an inch over the plates. In mixing the acid with the water, the acid should always be very slowly added to the water and not *vice versa*, as there is considerable ebullition and generation of heat. The first charge should be at half the ordinary rate, and for a period of rather more than double the prescribed time. When the cell is charged it will gas freely. The truest indication of the completion of the charging is the specific gravity of the acid. With small accumulators it is not possible to insert a hydrometer to test the specific gravity, but hydrometers are obtainable into which a small quantity of the acid can be drawn by means of a rubber bulb, the specific

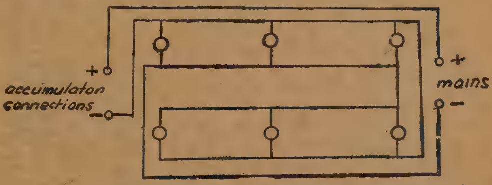


Fig. 7.—Connections for Lamp Resistance Board

gravity being indicated by the levels at which three coloured beads float. Rough tests can be made with a voltmeter, on which a 4-volt cell should give a reading of 4·5 volts if fully charged. Indication

is also afforded by a lamp of the correct voltage which should glow very brightly, and also to a certain extent by the colour of the positive plates which should be a deep chocolate. Voltmeter and lamp tests are best made after the cell has been working a short time, as there is always an initial current of a false value with a cell that has been newly charged, or has not been in immediate previous use.

Discharging.—The voltage of a cell should never be allowed to fall below 1·8 volts, or an insoluble sulphate will form on the plates, and the damage that will result from this will be irremediable. A slightly sulphated accumulator may be improved, if not entirelyrestored, byseveral alternate chargings and dischargings at an exceedingly low rate, but one that is badly sulphated may be regarded as ruined.

With proper care and certain precautions, the life of an accumulator may be almost indefinite. In the first place an accumulator is all the better for being in constant use, but if it is not in use, the voltage should be tested about every three or four weeks; if there is an appreciable fall the cell should be given a further charge; if the voltage of a 2-volt cell has fallen below 1·8 volts the necessity for recharging immediately is imperative. The charging rate should on no account exceed the maximum permissible, and the same statement applies to the rate of discharge. With regard to this latter it must be remembered that testing an accumulator by "flashing the terminals"—that is, momentarily short-circuiting the terminals by means of a piece of wire or metal—means that the maximum discharging rate is being greatly exceeded for the moment.

The acid should always well cover the plates, and loss that is bound to take place owing to evaporation and gassing should be made good with distilled water only, and not with a mixture of acid and water. The terminals and tops of the cases should be kept well coated with vaseline; especially is this the case when it is desired to put an accumulator away for a time and to bestow on it the smallest amount of attention. An accumulator should be stored in a dark, cool place, and be covered up so that dust does not reach it. There is one method only of keeping an accumulator in good condition and that is by keeping it fully charged.

The Care of Tennis Rackets

Few people can explain why the strings of a tennis racket snap suddenly without apparent cause. A player often stores his racket in a very dry, warm room, where it may be left many days at a time. Then it is taken on to a damp lawn. Now, gut strings are very susceptible to damp. Immediately the strings begin to absorb moisture the process of expanding takes place, and slackening of the stringing sets in during play. Play being over, the racket is taken back again into its warm room. Here the opposite process begins. The warm atmosphere begins to absorb the damp from the strings, and this time the gut strings contract. Now, if the stringing is of very high tension, some strings invariably snap. Whenever this does happen, it is always wise to have the strings replaced at once, otherwise the racket loses all tension, and sometimes the shape is absolutely destroyed, especially if left for a week or two. Get a waterproof head-cover for the racket, or make one out of a good piece of green baize, and sew on a piece of tape in the shape of a loop. Now insert the racket and place in a racket press. After screwing down, hang up by the loop on a nail in the scullery, not in a warm room. After a game, make a practice of rubbing the strings with a dry duster. Then smear a little sweet oil on the gut, and once or twice a month brush a small quantity of spirit varnish on all the strings.

Working Drawings: How to Prepare and Read Them

This chapter is an earnest attempt to deal explicitly with a subject which, while of extreme importance to all constructors in wood and metal, has been almost entirely neglected in the past. The neglect, it is to be assumed, arises out of the great difficulty of explaining the subject in a useful, lucid, and yet concise manner, and because an author, unless he takes for granted some slight knowledge of solid geometry on the reader's part, is appalled by the prospect of having to go back to such primary matters as the difference between a plan, an elevation and a section, and the methods of "projecting" one from the other. The difficulty has been faced in this chapter, and it is hoped that even the reader who is scarcely acquainted with geometry will find his understanding of the why and the wherefore of the working drawing built up bit by bit, until, by diligent application of the principles here laid down, he will be able to "read" any ordinary technical drawing which is ever likely to come in front of him. The subject may, and probably will, be regarded as "dry," but the amateur mechanic will find that the knowledge gained by studying this chapter will enhance the pleasure of his practical work and save both time and mistakes.

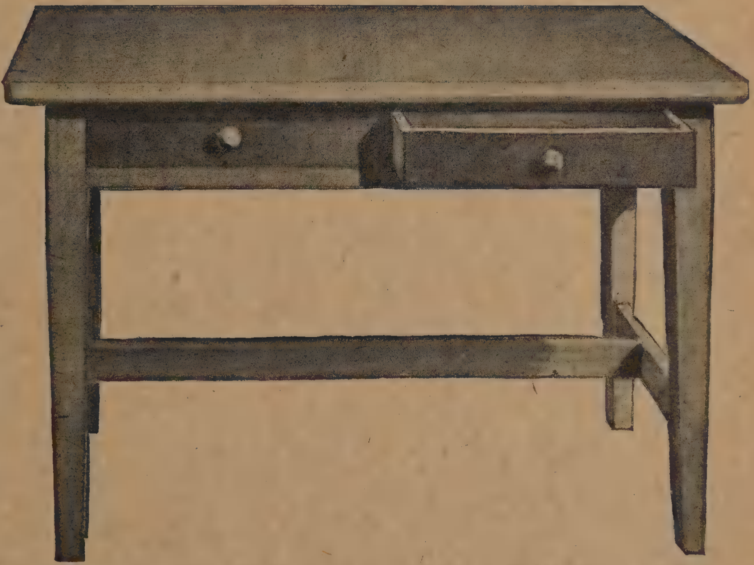


Fig. 1.—View of Small Kitchen Table

Briefly, the scheme of the chapter is as

follows: First, an everyday example of joinery work—a kitchen table—will be described in the style common among practical men. Next, the amateur will be shown how to interpret that information, and how from it, and the few drawings given, he may prepare for himself a full set of working drawings, including all the details. Much the same course will be followed with a second example—a kitchen dresser—and, finally, some hints on the drawing-board, the few draughtsman's instruments required, etc., and on their use and manipulation in the actual production of a working drawing will be given.

THE CONSTRUCTION OF A KITCHEN TABLE DESCRIBED BY ITS MAKER

The perspective (Fig. 1) shows a small kitchen table which was made more than thirty years ago, and which is still as strong and serviceable as ever. Its framing (see also Fig. 2) is of larch, which, although rather an uncommon wood for such work, is probably stronger and more durable than any other coniferous timber. However, either red or white pine may be used.

The table legs are dressed $2\frac{1}{4}$ in. square, and bevelled from the edge of the rails to $1\frac{1}{2}$ in. at the foot. The back and end rails are finished 5 in. by 1 in. The top front rail and bearer-rail for the drawers are $2\frac{1}{4}$ in. by 1 in., as is also the upright between the drawers, and the longitudinal and bottom rails 2 in. by 1 in. The table top is a solid 23-in. wide yellow pine board 1 in. thick by 3 ft. 4 in. long, and projects 2 in. over the framing at the ends and $1\frac{1}{4}$ in. at the front and back. Should a solid board of sufficient width for the top be unobtainable, the breadth may be made up by shooting the edges of two or more pieces, and dowel-jointing and gluing them together.

The stuff for the drawers is $\frac{3}{8}$-in. birch, with $\frac{5}{8}$-in. thick fronts, the latter being made of home-grown walnut, which when polished or varnished contrasts well with the lighter-coloured framing. The drawer knobs may be bought, but the writer turned them of the same stuff (walnut) as the drawer fronts, and, instead of the usual screwing, simply glued them in tight with plain turned pins, which still hold quite firmly.

The back and end rails are bridge mortised into the legs as at A (Fig. 3), and the end bottom rails as at B, while the front top rail is dovetailed into the top of the front legs as at C (Fig. 4) and the drawer bearer as at D. An end view of the front rails is given in Fig. 5. The upright E between the drawers is double-mortised into the rails F; but the tenons may be mortised right through and glue-wedged, which tends to prevent the weight and use of the drawer working the joints open at the shoulders. The drawer runner G is fixed between the bearer and back rail of the table with small blocks glued on underneath, as at H. The drawer guide is on top of the runner, as at J. The end runners are similarly fixed at both ends of the table as shown at K and L (Fig. 6). The longitudinal bottom rail is mortised midway into the bottom end rails with stump-tenon joints M (Fig. 7).

In putting the framing together, the end, top, and bottom rails are glued and cramped together, and then placed aside until the joints set. The short upright is at the same time glued into the front rails, and, in the latter case especially, care must be observed that the rails are not distorted from parallelism in cramping. Next, everything being prepared, the various joints are manipulated into their respective positions, with mallet or hammer, taking care not to bruise the wood, and finally cramped tightly together and tested for squareness. Any defect of this sort (provided the rails are correct for length and shoulders) should be remedied by slacking, and slightly altering the position of the cramp. It should also be noted that the bottom end-rail shoulders are bevelled to suit the legs.

The drawers are 1 ft. $3\frac{1}{2}$ in. wide and 3 in. deep at the front, and may be made 1 ft. 6 in. from front to back, dovetailed and glued together as shown in Fig. 8. As shown in Fig. 9, the drawer back is flush at the top and bottom with the dovetail pins, so that the grooving for the

bottom is flush with the under-side of the back, and permits the bottom being slid in from the back after the front, sides, and back are framed together. The fillets N (Fig. 8) are finally fixed to give breadth o, Fig. 9) and held in place with a fine screw-nail through it into the drawer back. Thus, if it shrinks from the front groove the screw can be withdrawn and reinserted after pushing in the bottom.

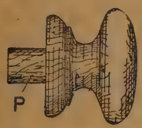
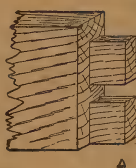


Fig. 10.—Drawer Knob



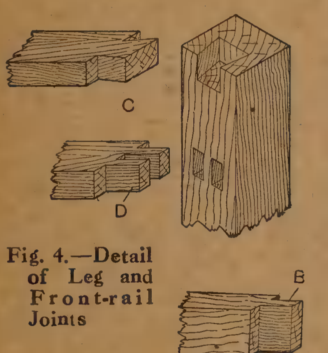


Fig. 4.—Detail of Leg and Front-rail Joints

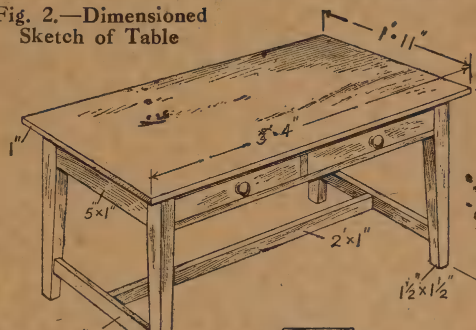


Fig. 2.—Dimensioned Sketch of Table

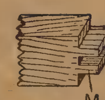


Fig. 7.—Joint of Longitudinal Rail

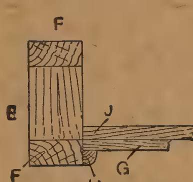


Fig. 5.—Detail of Upright and Middle Runner

Fig. 11.—Two Methods of Fixing Table Top

Fig. 3.—Table Leg with End-rail and Bottom-rail Joints

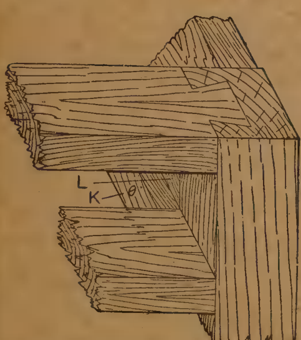
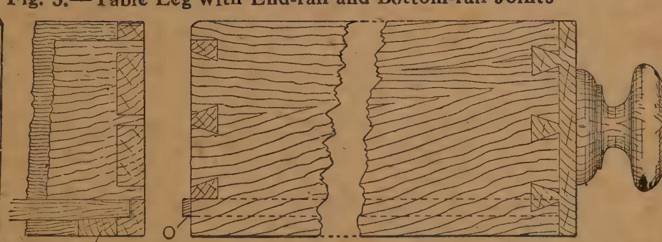


Fig. 6.—Detail of Front Rails and End Runners



Figs. 8 and 9.—Side and Rear End Elevations of Drawer

for wear, and prevent the thin drawer sides wearing tracks in the bearer and runners. As provision against shrinkage, which often occurs in drawer bottoms, the bottom may be advantageously left projecting a little beyond the back (as at

Fig. 10 shows the drawer knob with turned pin P for gluing into a bored hole.

Two methods of fixing the table top are adaptable from Fig. 11, either by glued angle blocks, Q, or angled countersunk screw-nails as at R; or the two combined.

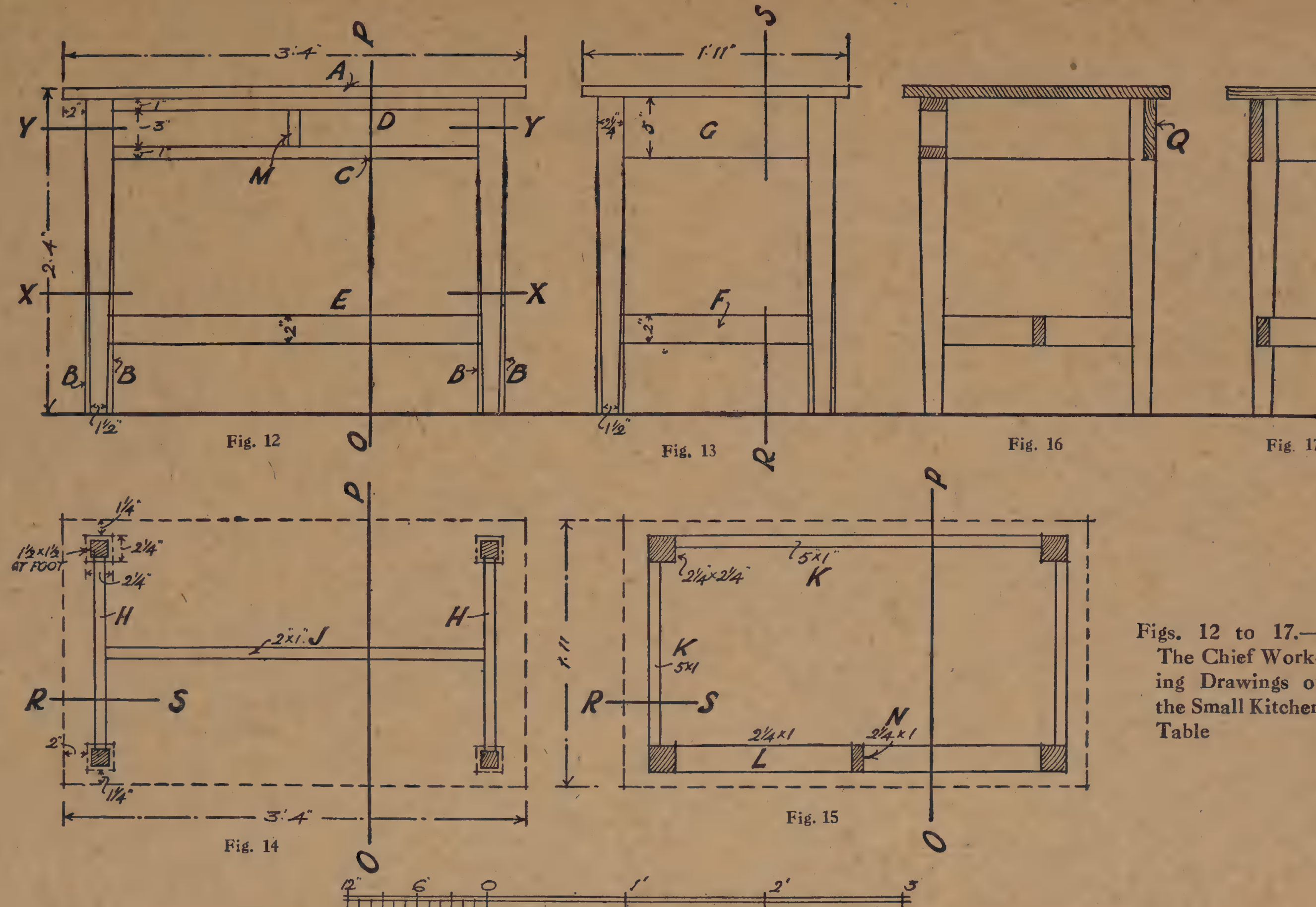
PREPARING THE WORKING DRAWINGS OF THE TABLE

Obviously written by an experienced man, the foregoing description, although intelligible enough to an amateur well grounded in the principles of joinery, will not be completely understood by the beginner, first, because of the use of technical terms, and, in the second place, because he will be in doubt as to the meaning of the drawings, the chief reason for the latter being that, either in saving space or addressing himself too exclusively to the well-informed worker, the author has omitted from his set of drawings the three most indispensable for the proper understanding of an object, namely, the elevation, section, and plan, and these terms it is now proposed to explain. It will be assumed that the reader is about to make the drawings in question, and, indeed, he is advised to do so, as by that means he will the more easily form a lucid idea of the whole subject.

First, it is proposed to make a rough drawing to a scale of one inch to a foot—that is, every inch actually measured on the paper represents a foot on the actual work; this can be readily done by the use of a boxwood or cardboard scale having on one edge inches divided into twelfths, each division representing an inch on the drawing.

The Front Elevation of the long side of the table—that on which the drawers sho —will be a view in some respects resembling Fig. 1 on p. 211, but with the important difference that the various converging lines caused by what is known as "perspective," such as those formed by the edges of the table top at each end, will not appear. If the eye be placed exactly level with the surface of the table and opposite the middle of it, the exact effect referred to will be seen; the board forming the top will appear simply a rectangle 3 ft. 4 in. long and 1 in thick, and the two drawers similarly will be quite rectangular. From this position, however, the eye would still look down upon the rails near the floor, and in order to see this portion in strict "elevation" it would be necessary to bring the eye down to only about 7 in. above the floor. This will perhaps make clear the requirements of an elevation, which are, in short, that each portion on the particular front concerned shall be shown as though the eye were exactly opposite to and level with it; this eliminates all question of converging lines such as would occur in a photograph, and, provided that the object is drawn either to its full size or to some scale, say one in which an inch represents a foot, it is possible to measure exactly the sizes of all the parts shown, which procedure would be obviously out of the question with such a view as that shown in Fig. 1.

To make a front elevation of the kitchen table from the information already given, supplemented where necessary, start by drawing the edge of the top (A, Fig. 12) 3 ft. 4 in. by 1 in. thick, to the scale of an inch to a foot, thus making a rectangle actually measuring $3\frac{1}{3}$ in. by $\frac{1}{12}$ in. (Note that Figs. 12 to 17 are reduced to three-fourths of this size.) It is ascertained that the top overhangs the legs at the ends to an extent of 2 in., and that the legs are $2\frac{1}{4}$ in. wide; this enables us to put in the four lines B B reaching from the under-side of the top to a horizontal line 2 ft. 3 in. below it, representing the floor level. Next we find that there is a bearer rail 1 in. deep for the drawers, C, also a top rail of the same depth immediately above them, and, as they are only 3 in. deep, it will be easy to measure the spaces and add the three horizontal lines indicating these members. There is also a short piece 1 in. wide to be shown in the middle to separate the two drawer-spaces D. At this point it may be observed that the legs are not parallel sided, as suggested by the lines B B, but that they are tapered towards the floor; this taper can be shown by measuring $\frac{3}{8}$ in. (to scale) in at each side at floor level, and then joining up with the straight portion at the level of C. The front and back legs are connected by a light rail near the floor (see Fig. 1); these rails are, of course, end on to the legs in one elevation, and consequently are not seen; but



Figs. 12 to 17.—The Chief Working Drawings of the Small Kitchen Table

the long rail connecting them along the middle of the table from end to end will require to be shown, 6 in. up from the floor and 2 in. high (E, Fig. 12). This will complete our front elevation for the purposes of a simple exercise.

The Side or End Elevation (see Fig. 13) should always be arranged level with the front one, so that the horizontal lines can be continued ("projected") along. The top can be drawn as before, but 1 ft. 11 in. across, and the legs added and tapered off as before, but this time only $1\frac{1}{4}$ in. from the edge. The rail previously mentioned as connecting the front and back legs will now be seen as at F, and as there are no drawers on this side, a plain piece, G, 5 in. deep, to agree with the bottom of C in Fig. 12, will be necessary to complete this view.

The Plan is primarily intended to show (to scale) what a thing is actually like on the ground level; but the idea can be applied to any other desired point. Thus Fig. 14 is a plan at the level of the line X X in Fig. 12. It can best be drawn by marking out to scale and immediately under the front elevation (with which it must agree) an oblong 3 ft 4 in. by 1 ft. 11 in. in dotted lines to indicate the position of the table top if laid flat on the floor. As this governs the positions of the legs it will be simple to mark them out $2\frac{1}{4}$ in. square, 2 in. from the ends and $1\frac{1}{4}$ in. from the front and back edges, as dictated by the previous description. It will, however, be recalled that they are tapered to $1\frac{1}{2}$ in. by $1\frac{1}{2}$ in. at the bottom, so that in order to be correct $\frac{3}{8}$ in. should be marked off all round each leg and the reduced square so formed hatched with light diagonal lines as shown. The rails between the front and back legs near the floor, and also the one running lengthways along the centre, will require to be shown in this plan, all 1 in. wide, as at H H and J. After this, it will be advisable to draw a plan at the level of the line Y Y in Fig. 12, or about the middle of the space for the drawers. The same procedure will be followed as regards dotting the outline of the top and showing the four legs in their correct positions, although at this level they are not reduced from the $2\frac{1}{4}$-in. dimension. At the ends and along the back are three 5-in. by 1-in. pieces, as at G in Fig. 13, flush with the legs on the outer faces and consequently shown merely by lines connecting the outer faces of the legs, and then adding the back edges at a distance of 1 in., as at K K. On the front, at this level, it is rather different, as the drawer bearer (C, Fig. 12), while only 1 in. high, is, for strength, $2\frac{1}{4}$ in. wide, and consequently the same width as the legs L. In the middle of it will appear the little upright division between the two drawer fronts (see M, Fig. 12), which is also $2\frac{1}{4}$ in. by 1 in., and will be seen on plan at N in Fig. 15.

The Section may be taken in either the vertical or the horizontal plane, and it shows an object as though it were actually cut right through with a knife, thus exposing to view its internal shape at that place. The line on which a vertical section is taken is usually indicated by a thick line, with suitable reference letters, on the plan.

Thus a *line* in an elevation or plan is represented in the corresponding plan or elevation by a *surface;* and a *section* is merely an internal elevation or plan.

Imagine the table at present used as an example sliced through by a vertical cut right down from the top, at the part indicated by the line O P on the plan (Fig. 14). These section lines are not usually shown on more than one plan, but, for purposes of demonstration, the present one is also indicated in Figs. 12 and 15. The supposed slicing would leave exposed such a view as that in Fig. 16, which would be described as "Section on line O P." Dealing in the present instance with a simple article, the section is found to be very similar to the end elevation (Fig. 13), except that the long bottom rail is cut through, as are also the table top, the drawer bearer and top piece, and the 5-in. by 1-in. piece at the back marked Q. For a complicated piece of work it is sometimes advisable to include other sections taken on lines cutting through the portion it is desired to explain, but

in the present instance the only other section that could possibly be considered necessary is of so simple a nature that it is quite useless to fill in the whole, so that the "Section on line R S" (Fig. 17) is a mere fragment. Its line is shown in Fig. 14 properly, and in Figs. 13 and 15 for demonstration purposes, as in the case of the other section. The reader will by now be qualified to observe for himself that Section R S shows a back leg with the short lower rail shown in section and part of the long one meeting it, while above are seen part of the table top with the piece corresponding to G in Fig. 13 cut through in section below it, and part of the back piece seen in section at Q in Fig. 16 now showing in elevation. Sections are frequently described, not by letters, but as being "longitudinal" or as "transverse" or "cross"; but for the present purpose this method is not so definite as the one advocated.

Detail Drawings.—When the work is first of all drawn to a scale, details made full-size are usually essential for the proper carrying out of the work. These details should be such that every part can be proceeded with in accordance with the drawings, and no part of the work left to be decided until the time when it actually has to be put in hand. A typical set of such details relating to the kitchen table already illustrated are reproduced in Figs. 18 to 27. These are dimensioned and figured fairly fully, although without undue repetition, and as they all conform to the usual workshop practice they will be sufficiently explicit for the carpenter or joiner without further explanation. To the novice, however, as yet perhaps none too sure of his understanding of plan and elevation, the view given by Fig. 28 will prove very helpful in explaining the various joints. The details (Figs. 18 to 27) will be seen to consist of simply an extension of the principle of plan and elevation already expounded, applied to each portion individually in order to show the various joints which are necessarily omitted on the smaller drawings.

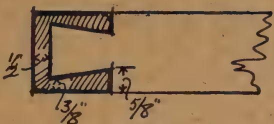
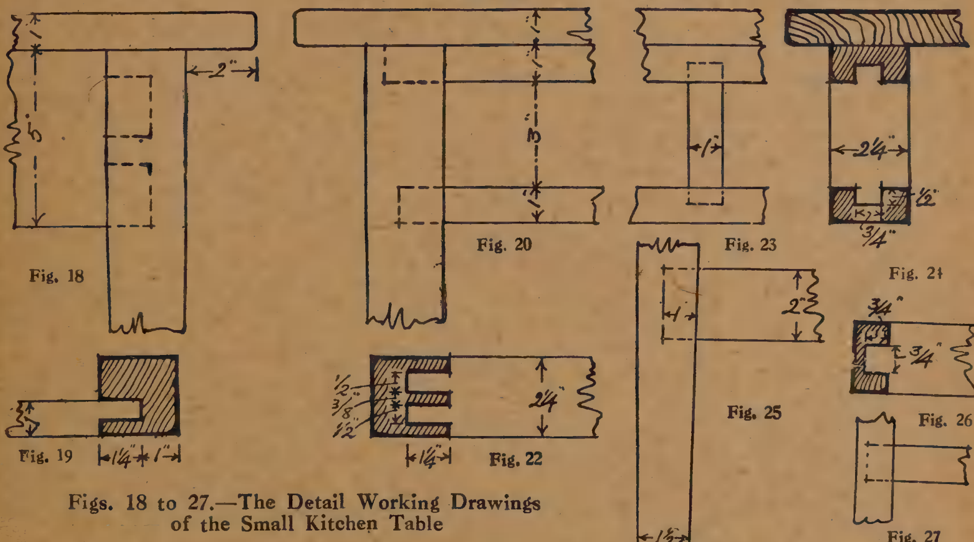


Fig. 21



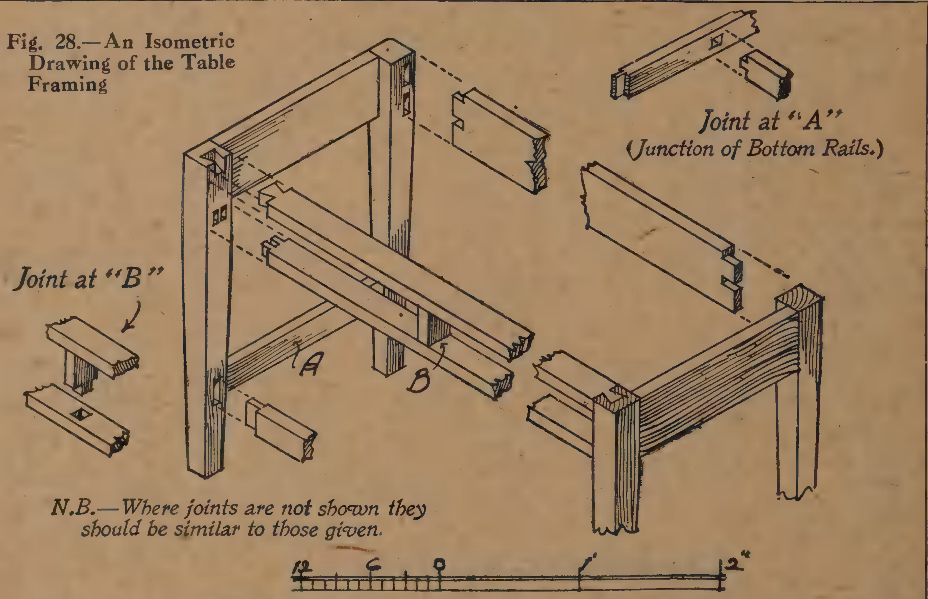
Figs. 18 to 27.—The Detail Working Drawings of the Small Kitchen Table

The explanatory drawings presented by Fig. 28 are really a crude form of "perspective," without the convergence of the parallel lines usually implied by the term. They are known as "isometric projections," from the fact that in them

it is possible to measure vertical and horizontal distances equally well on two faces of a rectangular object, which is, of course, quite impossible on an ordinary elevation. Isometric drawings are very useful for explanatory purposes, as in the present instance, but are seldom, if ever, used in practical work. The method required to produce them is quite simple, as all the sloping lines are at 30° to the true horizontal line; but it will be understood that, although these actually slope on the paper, they are the horizontal lines just referred to as being possible to measure along with accuracy.

The work described and illustrated so far is thought to have dealt fully with the whole structure, with the exceptions of the method of fixing the top to the framing and the simplest way to make the drawers. As these will apply equally to the next example and many other pieces of work it is proposed to deal with them later in this chapter.

Fig. 28.—An Isometric Drawing of the Table Framing



A SIMPLE KITCHEN DRESSER

The perspective view (Fig. 29) shows a simple kitchen dresser, the full working drawings of which are presented by Fig. 30 on p. 220. The dresser may be altered in size to suit varying requirements, and made either a fixture or removable, and also with or without a boarded back.

The lower part would be made quite separate from the upper portion, and consists of four 2-in. square legs having their tops stub-tenoned into a dresser top $15\frac{3}{4}$ in. wide and about $1\frac{1}{8}$ in. thick ($1\frac{1}{4}$ in. planed down), and with edges rounded off. A 2-in. by $1\frac{1}{2}$-in. bearer is tenoned between the front legs for the two drawers, which are separated by a 2-in. by $1\frac{1}{2}$-in. central upright (G on front view), tenoned at top and bottom. A 1-in. square fillet is fitted in just above each drawer without any joints, and this should leave about 10 in. for the drawers, which will be dealt with later in this chapter. Each of the ends is filled in with a 1-in. by $1\frac{1}{2}$-in. rail, tenoned between the front and back legs level with the drawer bearer, and the space above filled in with a $\frac{5}{8}$-in. panel fitting into rebates in the rail and legs. This work is shown by the detail at H, where a drawer runner, which should be of oak, is

also indicated. Near the floor the "top board" consists of $\frac{3}{4}$-in. boarding with rounded nosings carried on $2\frac{1}{4}$-in. by 1-in. pieces tenoned between the legs on all four sides and secured underneath with angle-blocks, as indicated on the elevations and section.

The shelving constituting the upper half of the dresser is supported by means of three 7-in. by 1-in. uprights of the desired height, connected at the top by a horizontal $\frac{3}{4}$-in. top board, nailed down on their ends. They are shaped at the bottom as shown by the detail at C. The edge of the top board will need making out with a small strip $\frac{7}{8}$ in. square right along the front, in order to make the edge out sufficiently to take a small moulded cornice of any desired profile, mitred round the top. On the left-hand side this part of the work will be finished with a 4-in. by $\frac{3}{4}$-in. spandril, $\frac{1}{8}$ in. back from the front edges of the supports, cut to a curve formed by a radius of 2 ft. 1 in.

Fig. 29.—View of Kitchen Dresser

Of the shelves, the bottom one on each side and the two under the arch are 7 in. by 1 in. (unless they are made $\frac{1}{2}$ in. less in order to allow for a thin boarded back), grooved for plates and dishes as on the detail at C, housed $\frac{1}{4}$ in. or $\frac{3}{8}$ in. into the uprights except for the front $\frac{1}{2}$ in. or so, which should be cut back so that they will simply butt against the perpendicular face. The three shelves in the cupboard should be similar, but $1\frac{1}{2}$ in. less wide to accommodate the door; they need not be housed like the others unless desired, as small fillets on the supports would carry them quite well and be concealed from view when the door is closed. The latter might be bought, or framed up in accordance with instructions given in other chapters, or even made up of similar stuff to that shown by the detail plan in the top right-hand corner, only mitred together at the angles as would be done with an ordinary picture-frame, instead of the more orthodox and, of course, stronger method of mortising and tenoning.

The top half will be found to stand quite safely upon the dresser top; but should it require any steadying, a couple of brass wall-plates, with which to attach it to the wall at the top, will be found quite satisfactory.

MAKING A DRAWER

The main requirements for a good drawer are smooth running, perfect fitting,

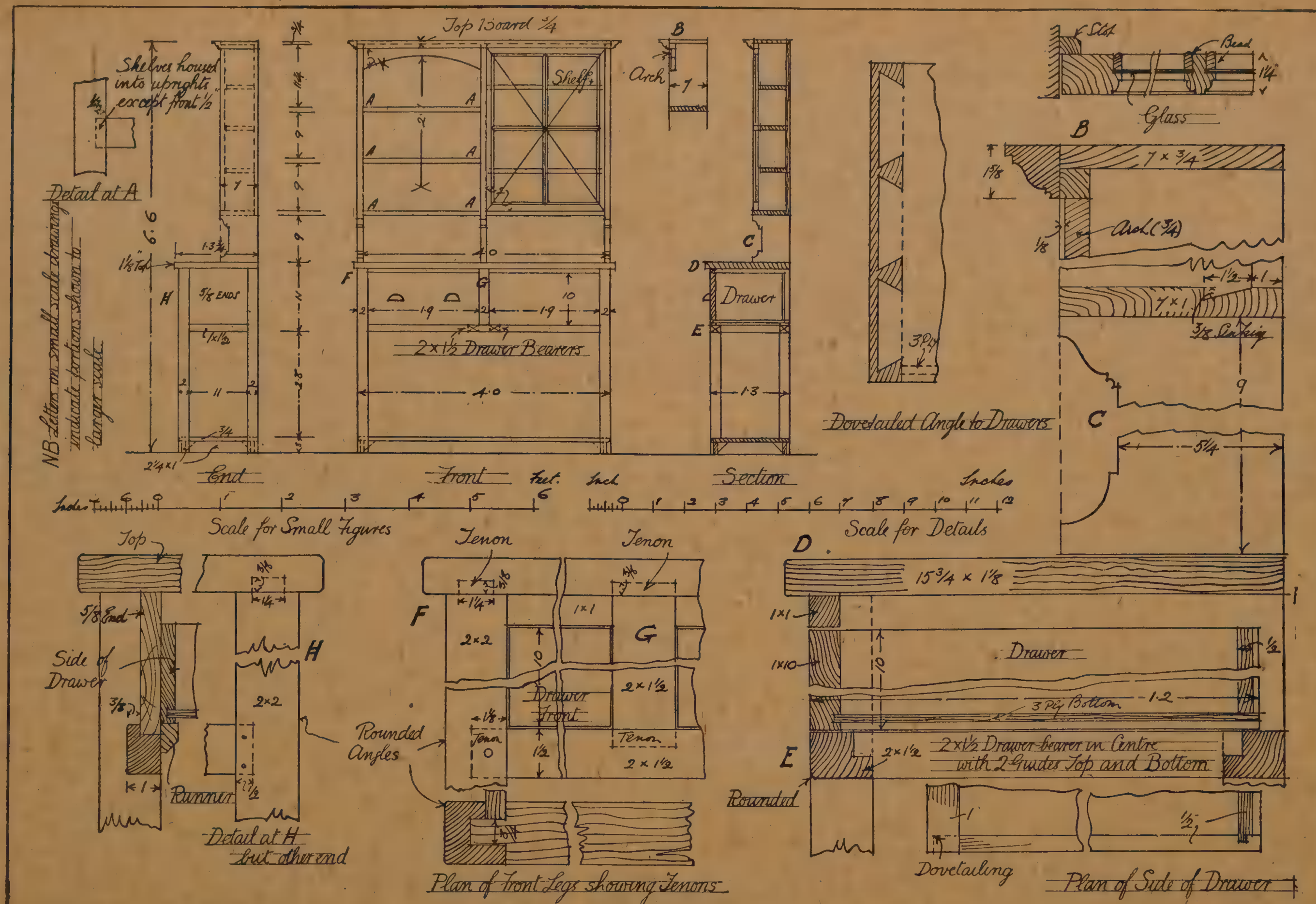


Fig. 30.—The Working Drawings of the Kitchen Dresser as the Amateur Should Prepare Them

and considerable strength, and in order to fulfil these it is essential to exercise great care when setting out the work. The details of the drawers for the kitchen dresser are explained by Figs. 31 to 33, and can be adapted for all three sizes. A 1-in. front is dovetailed to the $\frac{1}{2}$-in. sides as in Fig. 31, this joint being the best to resist the tendency to pull off the front when opening the drawer. Sometimes a large number of dovetails are advocated in such a case, but the practical man will find that this sort of thing can be easily overdone, and it is not worth while to put useless labour into such a part. A groove, A, should be worked round the lower edges of the sides and front to receive a thin bottom, which in most cases can be of three-ply wood slipped into the grooves from the rear and afterwards secured to the back piece, which, as shown in Fig. 32, stops at the top line of the grooves. This figure also shows how the back is rebated at each end to form a projecting tongue fitting into a vertical groove B. Two strips on the bottom, as at C and D in Fig. 33, will be useful to reduce the wearing of these upon the bearers on which they slide in and out. Rails and blocks should be fitted wherever possible inside the drawer space to act as guides, and there should also be a stop to prevent the drawer going the least distance beyond the front at which its face becomes flush with the surrounding framing.

It is usually advisable to make the drawer as a tight fit, and then to reduce it just sufficiently by planing on the outside for it to run easily when moved with one hand only; and it will be found advantageous to have the wearing parts in oak. Drawer-bearers in the centre, where the two drawers adjoin, can easily be fitted between the front and back rails. They are shown on the dresser details, but were omitted for the time being from the description of the table, this having been purposely dealt with in a somewhat elementary manner, avoiding all possible complications.

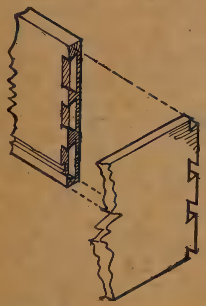


Fig 31.—Dovetailing of Drawer

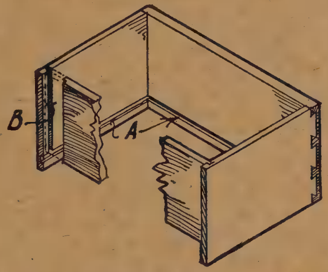


Fig. 32.—Inside View of Drawer, Showing Groove for Bottom

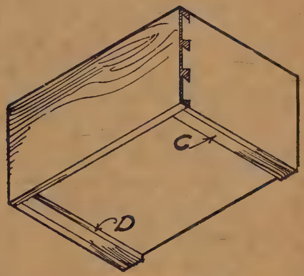


Fig. 33.—Strips on Drawer Bottom

FIXING A TABLE TOP

When the under-framing and table top have been prepared ready to fix together, there are several methods of joining them that may be adopted. First, there is the system of gluing small blocks on the under-side, as in Fig. 34, but unless these are also bradded or screwed they are sure to fall off sooner or later. Another course, already mentioned, is to insert screws in countersinkings, in the rails at intervals, as in Fig. 35. Both these methods, however, are open to the objection that they allow no latitude in case the table top shrinks or expands, so that it is highly probable that splits will occur owing to too great a rigidity of fixing. The best manner in which to execute the job is undoubtedly to work a groove all round the bearers and to insert at frequent intervals what are termed "buttons." These are of the shape shown in Figs. 36 and 37, with their end grain cut into tongues fitting rather loosely into

the grooves and then screwed to the top, which will thus be able to move a little and yet be firmly attached to its supports. Of course with the kitchen table this system could not be employed along the

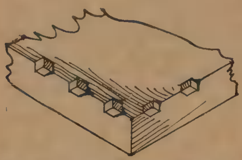


Fig. 34.—Glued Blocks Under Table Top

Fig. 35.—Table Top Held by Screws in Countersinkings

front above the drawers, there being insufficient height; but if it were to be adopted for the other three sides it would not matter if the front were fixed by the methods shown by Figs. 34 and 35.

REQUISITES FOR PREPARING WORKING DRAWINGS

The most useful kind of paper for working drawings of joiners' work is cartridge, although if there is a great deal of it to be done a fairly good quality linen paper, as sold by wallpaper merchants at about 1s. per piece, might be employed, but its surface will not bear much rubbing out. Sometimes, too, brown paper is worked upon with chalk; but this would hardly appeal to the amateur unless he were experienced.

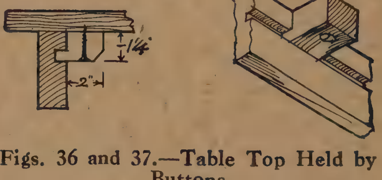
A sheet of tracing paper, obtainable from a stationer's, will be found useful on occasion, especially when there is any curved work to be repeated in a symmetrical design. Carbon paper can be used in such a case, but is messy stuff and better avoided. There is one variety of paper that may be found of use for preliminary sketches before the actual scale drawings are begun, namely, that divided into small squares by faint lines. These squares can be taken to represent inches, halfs or quarters, etc., as desired, and form a considerable guide and help when making tentative freehand sketches.

With regard to the instruments, etc., required, it will be as well to work upon a drawing-board if possible. A half imperial (22 in. by 15 in.) would be a suitable size, or this could be improvised by screwing some well-seasoned boarding on two battens (hardwood if possible) in such a way as to allow each board to expand or shrink without splitting. Smoothed off on the face, and with edges shot and corners rounded, this should make an efficient drawing-board. For only occasional work, however, it may be sufficient to use paper pinned down on a table or bench top, any irregularities being sufficiently smoothed over by means of a sheet of paper under the drawing.

A simple pearwood **T**-square 24 in. long, and one or two set-squares will also be required; they may be in pearwood, but should not have bevelled edges, as these limit their proper use to one side only. The transparent celluloid set squares are very convenient and clean.

A pair of compasses will be indispensable; they should be in brass, arranged to take an ordinary pencil. The pencil used in the compasses should not be harder than the H B degree, and if sharpened to a chisel point will be found to give a much better line and to last longer than if sharpened to a circular point.

When curves occur too large to be described with the compasses, a pin firmly inserted at the centre of the



Figs. 36 and 37.—Table Top Held by Buttons

desired curve and a piece of string carefully regulated to the correct length and having a small loop firmly tied at each end will be found quite sufficient for the purpose. A pair of dividers, costing, say, 1s., can be turned to account, although in most cases they are not absolutely essential. A 2-ft. rule is, of course, necessary; it had better be free from any scales, and should be used solely for full-size work. A separate **12-in.**

boxwood scale, having its four edges marked with 1 in., $\frac{1}{2}$ in., $\frac{1}{4}$ in., and $\frac{1}{8}$ in. to a foot, will be found of most service. The use of the two smallest scales lies not in the probability of a workshop drawing ever being made to this scale, but in the fact that when a larger drawing is desired than would be obtained by showing the work to 1-in. scale then the side divided into eighths of an inch can be taken as representing not feet but inches, thus giving a scale of $\frac{1}{8}$ in. to 1 in. (that is, $1\frac{1}{2}$ in. to 1 ft.), and the same with the $\frac{1}{4}$-in. scale, which can be made to serve as one of 3 in. to 1 ft.

A mistake very often made is that any pencils used should be hard ; this renders the work thin and scratchy, as well as tedious to produce and difficult to erase and alter. An H B or F will give much better results for small work, while for full-sizes, curves, or writing, a B degree affords more freedom and rapidity, and at the same time is much more easily deciphered. Very often, especially in full-size work, it is advisable to avoid confusion of the various lines and parts, and for this reason coloured pencils may be used, perhaps adopting blue for the dimension lines, red to elucidate any portions indicated behind some other part, green for glass or metal, and brown to shade the sectional portions of the woodwork. Much the same result would be obtained by the use of water colour applied with a brush, but this is not often done in ordinary workshop practice.

Reversing Drawings.—The operation of tracing previously referred to is of value when a full-size design is furnished, say, in a book, or when one-half of a symmetrical figure has been drawn and is required to be reproduced on the reverse. It is, of course, done by going with a soft pencil over the outline as seen through the transparent paper, turning this over on to the desired place, and again going along the outline as seen through from the other face This, if carefully done, will be found to transfer a fairly accurate replica, which can easily be touched up if at all defective. The tracing can usually be again reversed if necessary, but by this time the paper will most probably be nearly cut through. In any case the success of tracing work depends very largely upon the careful pinning of the papers in position, as any movement, even if only slight, tends to throw the whole thing out. Drawing pins for this and other work should be large, strong ones, and selected for their smooth heads in order nor to impede the T-square unduly.

Enlarging Drawings.—It is usually quite a straightforward matter to enlarge working drawings from printed examples by means of the scales and dimensions invariably shown ; but where any elaborate work, such as a fret ornament or piece of carving, has to be enlarged, the copy should be divided by pencil lines at right angles into small squares corresponding with a similar series of squares on the full-size setting out ; thus, should the copy be a quarter full-size, it will have $\frac{1}{4}$-in. squares as compared with 1-in. ones on the enlargement, and the process of numbering both sets of squares up and across in order to prevent mistakes, and then copying the design square by square, will be very simple. However, simple as the work is, it calls for some little skill in freehand drawing.

Some Precautions in Setting Out.—In conclusion, it may be noted that when setting out woodwork there are several points to bear in mind. Allowance must always be made for the reduction of the various thicknesses by the necessary planing of the surfaces, and a certain amount of play or movement should be allowed panels, etc., in order to render them less liable to splitting.

Summerhouses: Designs and Construction

An Octagonal Summerhouse. — The charm of any garden, large or small, is enhanced by an appropriate arbour or shelter, and the summerhouse shown below by Fig. 1 has been designed to harmonise with a background of foliage, at the same time avoiding the old-fashioned rustic type. It will be found

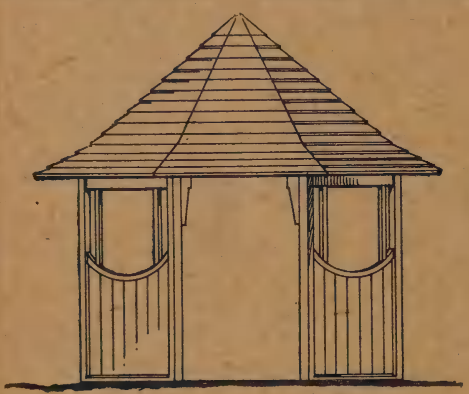


Fig. 2

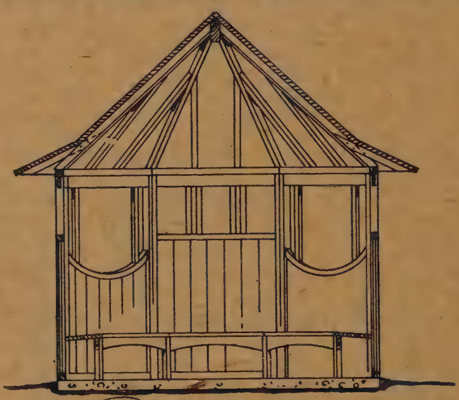


Fig. 3

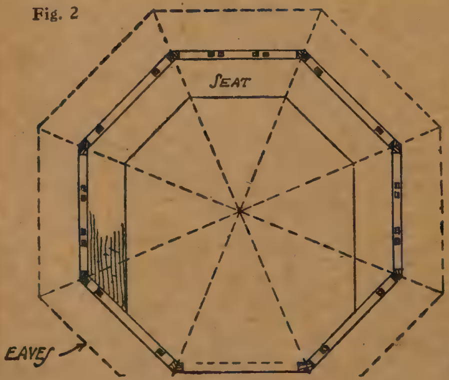


Fig. 4

Fig. 1.—Octagonal Summerhouse

Figs. 2 to 4.—Elevations and Plan of Summerhouse

commodious, and sheltered on all sides except the front.

As illustrated by Figs. 2 to 4, it measures 10 ft. across, but this can be altered as desired. Its construction is as follows: A 2-in. by 2-in. sill all round the octagon is bedded on a 4-in. layer of concrete, finished smooth surface and sloping outwards, and at the angles, uprights, each composed of two 2-in. by 2-in. posts shaped as on plan, are fixed. These carry a roof plate similar to the sill, and at each hip a rafter of about 4 in. by $1\frac{1}{4}$ in. is notched on the plate and firmly spiked to a centre-piece at the apex, which can be turned and allowed to project above the roof if desired. Between the hips two small rafters are fixed, and at the foot of each a "sprocket" is fixed (see section), making the roof a flatter pitch at the eaves. This can be omitted, but it is remarkable what an addition it is to the general effect.

In any case, it should be said, the eaves must project 1 ft. 3 in. to look really well, and they form the best protection against both rain and sun.

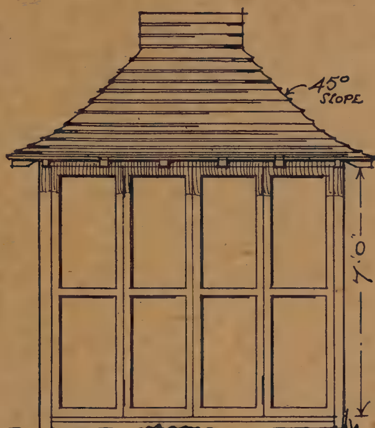


Fig. 5

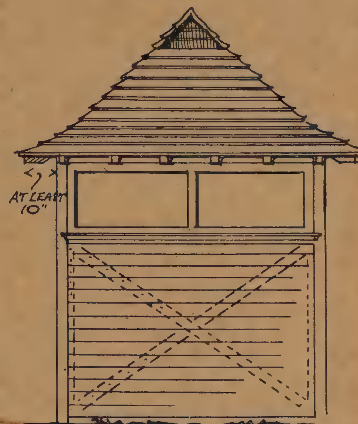


Fig. 6

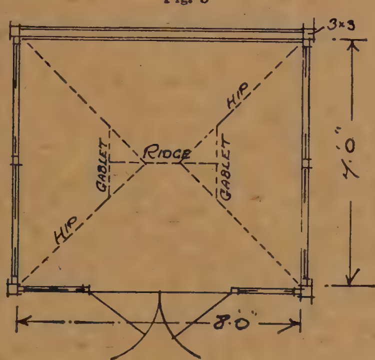


Fig. 7

Figs. 5 to 7.—Elevations and Plan of Square Summerhouse

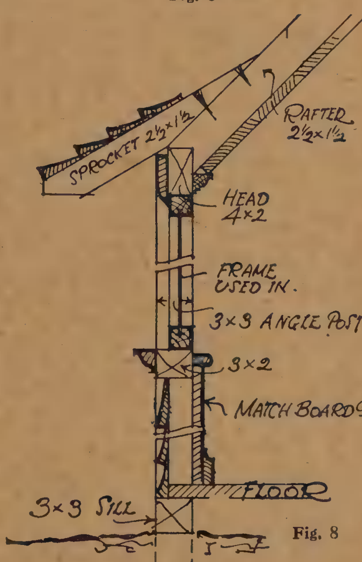


Fig. 8

Fig. 8.—Detail of Summerhouse Construction

Four alternate sides have a curved rail, which should be rebated on the outside (as also the sill below), and filled in with matchboarding. Three of the remaining sides have a horizontal rail 4 ft. 6 in. above the floor, and similar boarding. Round seven sides is fixed a fascia 4 in. by 1 in. between the posts under the roof plate,

and below this fascia are fixed 2-in. by $\frac{3}{4}$-in. uprights as shown, two of these being fixed to the curved rails and four to the other sides. The entrance has two shaped brackets 1 in. thick instead of the fascia, and at least 6 ft. 6 in. head room should be allowed.

As regards the interior, this can be fitted up as required; seating on light bearers is indicated, but the seats should slope to be comfortable. Roofing is an important consideration, and weather-boarding on felt or Willesden paper is recommended. The roof should be treated with one of the well-known preservatives now on the market, and the work below can be stained or painted. If it can be renewed fairly frequently nothing looks better than white paint.

Fig. 9.—Sketch of Corner or Angle Summerhouse

A Square Summerhouse.—The summerhouse shown by Figs. 5 to 7 was designed to utilise six glazed frames measuring 7 ft. by 2 ft. The angle posts, 3 in. by 3 in., should be set in the ground, with 3-in. by 3-in. sill frames between. The head having little possibility of support on three sides, should be 4 in. by 2 in., the intermediate studs and diagonal braces (which will be covered by the boarding on both sides) put in to suit of 2-in. by 2-in. stuff. Existing frames are used for the front, and at the sides it will be better to use these lengthwise as shown, keeping their tops level with those of the front, and framing a 3-in. by 2-in. rail under, with a moulding along the front of this. Three-inch by 2-in. hips and $2\frac{1}{2}$-in. by $1\frac{1}{2}$-in. rafters would do for the roof, the hips going up to a short ridge-piece, and the small gablets being formed afterwards in boarding only. This finish will be found far better in appearance than a pyramid roof rising to a point, and will be further improved by bending the eaves out as far as possible (10 in. being shown as the minimum) by means of the small shaped sprockets shown in the detail (Fig. 8), nailed on top of each rafter to curve out the weather-boarding as shown on the elevation, the sprockets showing under as rafters. The latter will need no intermediate support, and will be matchboarded underneath, finishing with a small moulding at the bottom of the slope, while the boarded inside lining should have a small capping and skirting as indicated.

A boarded floor may be laid on the top of the sill, and on intermediate plates laid on the ground surface to suit; but rot is bound to set in sooner or later, and either an impervious floor or a layer of concrete to take the woodwork is strongly advised.

An Angle Summerhouse.—The somewhat unusual shape of the summerhouse illustrated by Figs. 9 to 12 is accounted for by the intention of placing it across one corner of a wide grass-plot, a view of which it would command, while it would soon be deeply recessed among some fast-growing and leafy shrubs. Being placed in such a position, it would, it is thought, have an appearance of greater novelty and charm than if placed centrally in a garden or detached from any large amount of foliage.

The construction is simple, and the dimensions can be varied as may be desired. As illustrated, the width across the front is 9 ft., and the depth from front to back 5 ft. 3 in. The opening in the front is 6 ft. wide and 6 ft. 3 in. high in the centre; while from the ground to

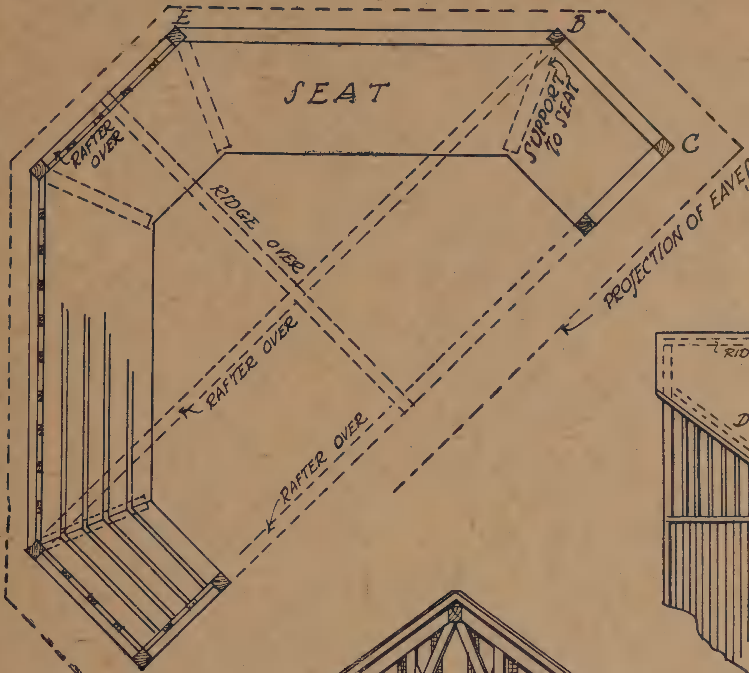


Fig. 10.—Plan of Angle Summerhouse

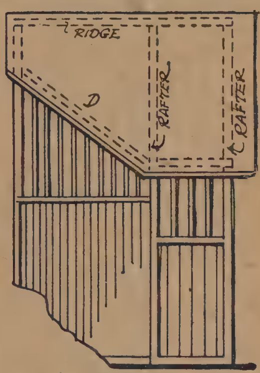


Fig. 12.—Side Elevation of Summerhouse (to Smaller Scale)

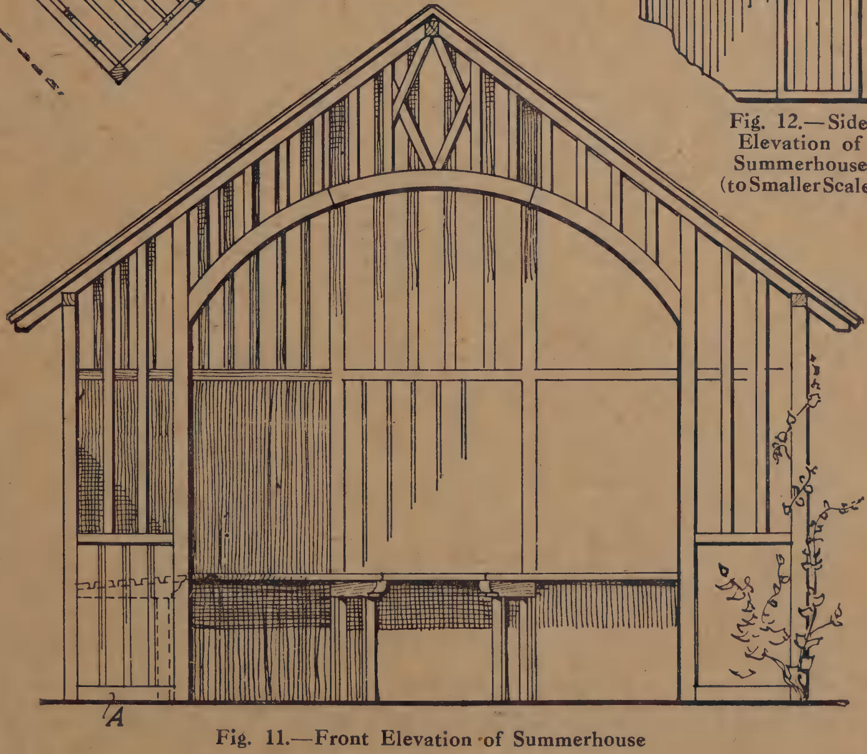


Fig. 11.—Front Elevation of Summerhouse

the eaves is 5 ft., and to the top of the ridge about 8 ft. 3 in. In any alteration of these sizes it should be remembered that the effect of this design depends on the proportion, which should not be altered without due consideration. In the present case the whole front, including the opening, should be kept very low in comparison with the width. An erection which soars high in the air and finishes with a weather vane or terminal is often very garish in appearance.

The site of the shelter having been marked out, it should be covered with a bed of concrete finished smooth, or a layer of gravel made hard and solid by the addition of a little portland cement, and arranged so as to slope towards the entrance, in order to keep the floor of the summerhouse in a fairly dry condition.

The main framework, consisting entirely of say 2-in. by 2-in. battens, is then taken in hand. It consists of eight upright posts (shown in the plan) of the various heights required, with their ends tarred if possible and bedded in the ground, while on the edge of the concrete or gravel between these posts are fixed sill-pieces, as at A (in the front elevation). The posts B and C support a horizontal head 5 ft. up, and over this two sets of rafters are cut to fit; they slope at an angle of a little less than 45°, overhang 8 in. at the eaves, and are spiked to a central ridge.

When this stage has been reached the slope of the roof will be defined, and it will be noticed that while the ridge and slope are continuous from front to back, the eaves are cut away as at D in the small sketch of the side elevation. This is the only really difficult part of the work—namely, the fitting of the head at D, and the exact height of the post at E (see plan). These could, of course, be elaborately set out on paper, but for the present purpose it is probably better to recommend a careful trial, shaping the ends gradually with a chisel and adjusting, until when a board is laid across the first two rafters it will rest evenly on D, without winding up or down. With two short rafters at E the roof can be put on; it will consist of weather-boarding or rough boards laid across the rafters and nailed to them, and projecting 8 in. in front. If ordinary boarding is used it must be covered with felt or some similar material. Weather-boarding is undoubtedly superior in appearance.

Rails are next fixed between the posts, 2 ft. from the ground in front, 3 ft. between B and C, and 4 ft. for the remaining sides. These rails are rebated at the top and bottom on the inside, and the heads and sills should also be rebated before fixing in order to take mat hed-boarding filling in the lower parts, and laths about 1½ in. wide spaced out as shown for the upper parts.

The arch over the entrance is then prepared out of 1½-in. boards in three pieces, held together by small metal strips on the inside. The lower edge is curved to part of a circle 3 ft. 6 in. in radius. Above this curve the space is filled in with vertical laths as before, except in the centre, where they form a diamond as shown.

Brackets put together as indicated in the front elevation, and with their tops sloping slightly, will be required for the seating at each end and at the angles. Narrow boards with rounded edges are nailed on with small spaces between and mitred as indicated in the plan, thus completing the shelter, which can be stained or painted in the usual manner.

As previously mentioned, the part D is the only difficult piece of work; and while most workers will prefer to employ a few halved or tenoned joints, yet the construction will be quite sound if the various members are simply spiked or nailed in position.

Screw Cutting

PRIOR to the year 1841, every manufacturer of machinery used his own shapes and sizes of screw threads, and this practice led to great inconvenience and delay. Very few firms were able to supply a replace screw that would fit, as there was no system in use that permitted interchangeability; as a consequence, when a screwed part of a machine gave way, the accurate duplication of the old part was a doubtful operation. Sir Joseph Whitworth, the English engineer, noticed the difficulty that resulted from the use of threads that had no recognised standard proportions, and in the year 1841 devised a system that has since been generally adopted for many parts of machines. Many threads have been devised or recommended by the Engineering Standards Committee (E.S.C.) for purposes where a large thread, such as the Whitworth, would not suit because of its depth and coarse pitch.

Whitworth Thread.—The Whitworth, or English Standard thread, is shown in Fig. 1, the angle being 55°. One-sixth of the height from 0 to 6 is rounded off at the top and bottom of the thread in order to prevent damage and to reduce the risk of the bolt breaking at the root of the thread. The smallest size of Whitworth thread recommended by the E.S.C. is $\frac{1}{4}$ in., and the largest 6 in.

American Standard Thread.—The American Standard, or Sellers thread (Fig. 2), is made with an angle of 60°, and one-eighth of the height, 0 to 8, is cut off the top and bottom, leaving a flat one-eighth of the pitch in width. American manufacturers claim that the Whitworth thread is much more expensive to produce than the Sellers thread, and the writer agrees with this view, since the correct rounding of the top of the British thread takes considerable time and care, every pitch of thread requiring a different curve. At the same time, the writer is of opinion that the Whitworth thread is worth the extra trouble, as sharp internal corners often cause fractures.

British Association Thread. — The British Association thread (Fig. 3), such as is used by electricians and others who require small screws, has been recommended by the E.S.C. The angle of the thread is $47\frac{1}{2}$°, and the top and bottom are both rounded to the same radius, this being two-elevenths of the pitch. In Fig. 3, D equals depth, P the pitch, and R the radius of the bottom and top of the thread.

Other Standard Threads.—There are other standard threads, such as the International Standard thread, which was recommended by the International Congress for the standardisation of screw threads, called together in 1898 at Zurich, in Switzerland; the angle of this thread is 60°, as in the American Standard thread. The Swiss or Thury thread has an angle of $47\frac{1}{2}$°, and one-fifth of the height is rounded off at the top and bottom. The sharp or V thread (Fig. 4), which is often used in America, has an angle of

60°, and the top of the thread comes to a fine point, as also does the bottom of the groove. The thread adopted by the Cycle Engineers' Institute (see Fig. 5) has an angle of 60°, and has the top and bottom of the thread rounded. In Fig. 5, H equals 0·866 of the pitch P, and D equals 0·5327 of the pitch. The smallest size has 62 threads per inch, and the largest has twenty-four threads per inch.

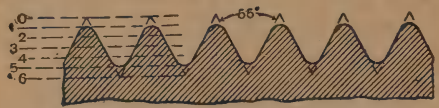


Fig. 1.—English Standard, or Whitworth Thread

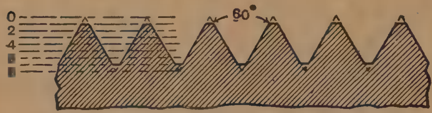


Fig. 2.—American Standard, or Sellers Thread

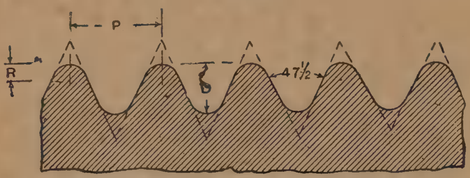


Fig. 3.—British Association Thread

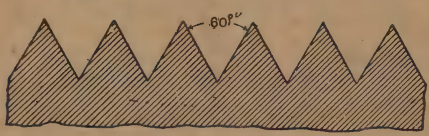


Fig. 4.—American Vee or Sharp Thread

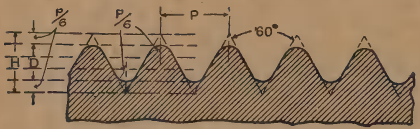


Fig. 5.—Cycle Engineers' Thread

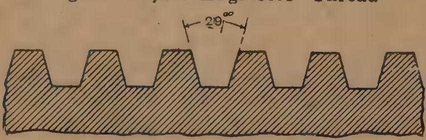


Fig. 6.—Acme Thread


Fig. 7.—Buttress Thread

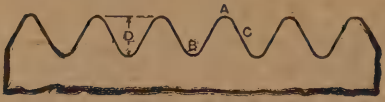


Fig. 8.—Diagram Illustrating Screw Definitions

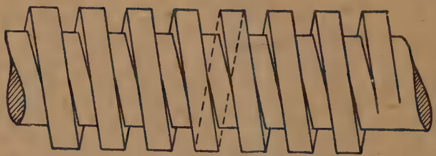


Fig. 9.—Single Square Thread

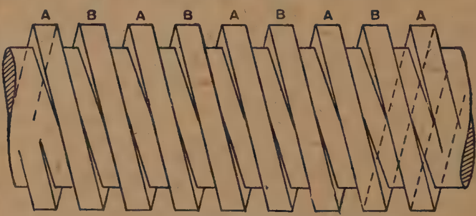


Fig. 10.—Double Square Thread

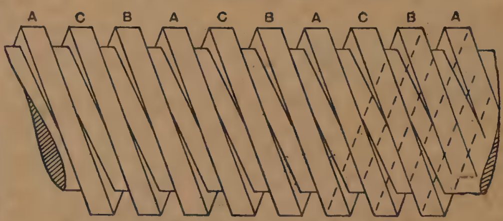


Fig. 11.—Triple Square Thread

Special Threads.—The Acme thread (Fig. 6) is largely used in machine tools, such as screw-cutting lathes where a disengaging nut is fitted. The angle is 29°, and this has been almost universally adopted as the angle for worms such as are used in reduction gears.

The Buttress thread (Fig. 7) has one side at an angle of 45° and the other side vertical; this form of thread is often used

in mechanism where the thrust or wear comes in one direction ; hydraulic presses and heavy siege guns are examples of such machines.

Square threads are so arranged that the depth and width of the thread are equal to the space.

Definitions.—The top of the thread is the part upon which the screw is measured (see A, Fig. 8) ; it is usual to measure all English screws over the tops of the

Fig. 12.—Stock and Dies

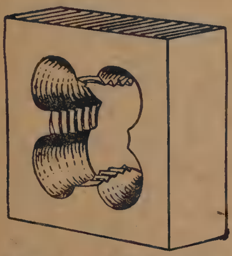


Fig. 14.—Machine Die

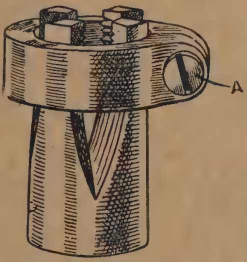


Fig. 16.—Spring Die

thread. In some instances American screws are measured at the bottom of the thread B ; this portion is often called the root. The depth of the thread is the distance D between the top and the bottom of the thread, or the amount that the thread projects. The slope of a thread is the angle of the sides C.

A right-hand screw is one that is turned clock-wise when it is tightened up—that is, it is turned in the same direction that the hands of a clock rotate. A left-hand screw is the opposite to a right-hand screw ; it turns anti-clock-wise.

A single thread (Fig. 9) has only one spiral groove cut round the bar, and, therefore, the thread is continuous. If one piece of string is wound round a cylinder it will resemble a single thread. A double thread has two spiral grooves cut around the bolt, and, consequently, two continuous threads, A and B (Fig. 10). If two pieces of string are wound together round a cylinder, a good idea of a double thread is obtained. A triple thread has three separate spiral grooves cut round the bar, thus producing three continuous threads. In Fig. 11 three separate threads, A, B, and C, are shown. Three pieces of string wound together round a cylinder will give a true idea of a triple thread.

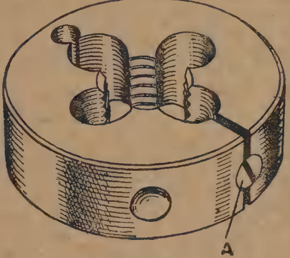


Fig. 13.—Adjustable Die

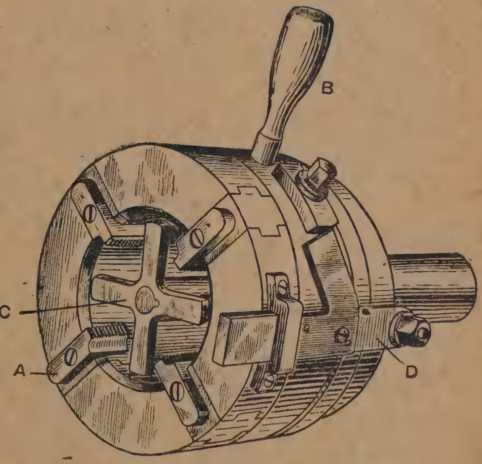


Fig. 15.—Self-opening Die Head

CUTTING EXTERNAL THREADS WITH HAND TOOLS

External threads may be cut by several methods : (1) By hand dies (for single threads), in which the die is generally passed over the material several times in order to cut a full thread ; watchmakers' screw plates are examples of this class of die. In the case of very small

screws, the thread can be formed in one cut by means of circular adjustable dies. This method (1) does not require a lathe; whereas for the other methods a lathe or other machine is necessary. (2) By machine dies, which are passed once only over the work in order to cut a full thread; this form of die is sometimes made solid, the lathe or other machine being reversed in order to free the die; but more often the die is so made that when it has screwed far enough, the cutting blades automatically open, and so allow the die to be returned rapidly to the starting position. (3) By hand chasers, which are lathe tools frequently used in brass work. (4) By single- or multiple-pointed tools, which are held in the slide-rest tool post of a screwing-cutting lathe.

Dies.—The hand dies, or stocks and dies (Fig. 12), are generally used for sizes from, say, $\frac{3}{8}$ in. upwards. With this tool, several cuts are taken down the bar before the complete thread is formed, the dies being closed in by means of a set-screw. As a rule, dies of this character soon lose their cutting edge unless abundantly supplied with oil and used discreetly.

With circular adjustable dies (Fig. 13), the thread is cut by passing the die once over the work. These dies are fixed in a hand wrench by means of one or more pointed screws, which are also used for closing in the die when the threads are slightly worn; before this adjustment can be made, however, a small, tapered screw A, which is fitted into a saw cut, has to be screwed out slightly to allow the die to be closed. Only small threads can be cut with these dies, as considerable physical exertion is necessary to cut large threads at one operation.

Machine dies (Fig. 14), as their name implies, are generally used in some form of screwing machine. They are mostly made solid, as shown, and are thus unadjustable. These dies are frequently used with a spanner for passing over bolt threads that have been roughly screwed in a machine, this reducing the thread to correct size.

Automatic self-opening die heads (Fig. 15) are generally used in automatic machines, and are consequently of but small practical interest to the amateur. They pass over the work once only, and when a sufficient length is screwed, the cutting parts automatically open outwards, allowing the die head to be drawn back for further use. The die head shown in Fig. 15 is arranged for screwing tapered work, after which it automatically opens. The dies A are first closed by moving the handle B circumferentially. When in use, the work pushes against the cross-piece C, and causes it to retreat as the die is advanced over the work; when the cross-piece C has reached a predetermined position, the cutting dies A automatically open. The device D allows of adjusting the cutting dies.

Spring dies (Fig. 16) are often used in various machines, but they have the disadvantage that the work has to be reversed in order to allow the die to be withdrawn. The dies are prevented from splitting open by means of the collar shown, which is placed over the cutting end of the die, and secured by tightening-up the screw A. The collar is also used for adjusting the die for size.

CUTTING INTERNAL THREADS WITH HAND TOOLS

Internal Threads are cut (1) by hand taps; (2) by collapsible taps, which close inwards and permit of their withdrawal from the hole; in order to get the tap out, solid taps require to be reversed or the work to be turned backwards; (3) by hand chasers, which, as in the case of external threads, are greatly used for brasswork; (4) by single- or multiple-pointed tools held in the tool post slide-rest.

There are other methods of screwing, but they are not of interest to the amateur.

Using Taps.—Three taps are generally used for tapping holes by hand. The taper tap (Fig. 17), which will easily enter the drilled hole, is used first, and is followed by the second tap (Fig. 18), this cutting away a further amount of material. The thread is finally cut to size by means of the plug tap (Fig. 19).

Fig. 17.—Taper Tap

Fig. 18.—Second Tap

Fig. 19.—Plug Tap

Fig. 21 Fig. 22 Fig. 23

Figs. 21 to 23.—Small Head or Fine Taps

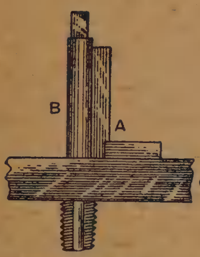


Fig. 20.—Testing for Squareness when Tapping

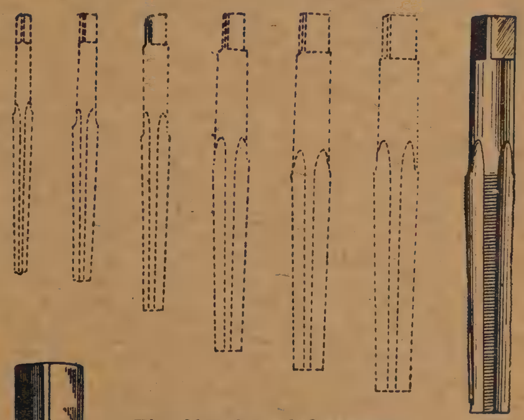


Fig. 30.—Set of Cycle Taps

Fig. 27.—Pulley Tap

Figs. 28 and 29.—Machine Taps

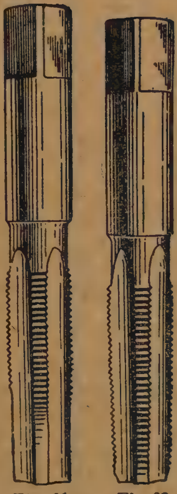


Fig. 31 Fig. 32

Figs. 31 and 32.—Boiler Taps

Fig. 24 Fig. 25 Fig. 26

Figs. 24 to 26.—Gas Taps

Small holes can often be cut by means of the taper tap alone, but this procedure is not recommended, as the tap is easily broken, and the thread is slightly larger than standard at the top.

In the tapping of large holes, considerable force has to be applied to remove the material, hence the necessity of using several taps; each tap removes a small quantity of metal at a time, so lessening the amount of exertion that is necessary.

When using hand taps, plenty of oil should be applied, and great care taken when turning them round by means of the wrench. They should constantly be moved backwards and forwards, and should not be forced to turn; after some experience it is not difficult to feel when the taps are cutting up to the limit.

Taps for use in a machine are made very long and with a slight amount of taper, which allows of the removal of only a small amount of metal at a time. If ordinary taps were used, they would be constantly breaking, owing to the drive being purely mechanical and insensitive. In machine tapping it is usual to run the tap through the hole once only, hence the necessity of a tap with a long taper.

Large holes are generally screwed in a machine by means of a collapsible tap, which, however, is scarcely likely to be used by the amateur.

To test whether the tap is square to the material, a square A (Fig. 20) is placed against the shank of the tap B; the material is indicated at C.

The breakages of taps is frequently due to misuse, such as applying too much force, trying to turn the tap when at the bottom of a blind hole, neglecting to sharpen them, and applying extreme torsional stress when endeavouring to force a dull tap into a small hole.

Grinding Taps.—Taps can easily be sharpened by grinding the forward or cutting face of the groove by means of a small emery-wheel. Of course, repeated grindings will result in the tap cutting a small hole; but within a certain limit very little harm will be done.

Various Taps.—The ordinary form of tap is made in three shapes for one size, consisting of a taper, second or intermediate, and plug tap as already illustrated by Figs. 17 to 19.

Better results are obtained by having four flutes in a tap instead of three, since another cutting edge is presented to the material being tapped. Apart from this, another groove is provided, thus giving greater facility for the escape of chips.

When taps are made for sizes below $\frac{1}{4}$ in. in diameter, they are shaped as shown by Figs. 21 to 23. The Engineering Standards Committee does not recommend a Whitworth thread below $\frac{1}{4}$ in. in diameter, and it thus follows that for the smaller taps a finer thread, such as the B.S.A., is used.

The taps shown by Figs. 24 to 26 are those used for Whitworth standard gas threads. The paper and plug taps are for use in parts where the holes to be tapped have been drilled the correct tapping size. The conical tap is intended to be used for tapping holes in flanges and sockets into which screwed pipe is to be tightly fitted.

When the boss of a pulley is tapped for a set-screw, it is usual to drill a large hole in the rim of the pulley in order to allow the tap to pass through freely. For this reason it is necessary to use the tap shown by Fig. 27, in which the shank is of such a length that the square can project clear of the rim, and allow a wrench to be used.

Machine taps (Figs. 28 and 29) are of small practical interest to the amateur; they have a long taper, so as to allow the material to be gradually cut out, and they also have a long shank to accommodate nuts as they pass over the thread.

Cycle engineers' taps (Fig. 30) are so graded as regards size ($\frac{1}{4}$ in. to $\frac{5}{8}$ in.) that when one size is screwed into a hole the full length of its thread, the point of the next larger tap will enter.

In the boiler tap (Fig. 31), the full thread is parallel, and the reamer at the point is used to size the hole and to remove any roughness. The point also serves as a gauge for the size of the drill to be used before tapping. The tap shown

by Fig. 32 is slightly tapered in order to make a steam-tight fit. Fig. 33 shows the tap used for screwing holes for stay bolts in boilers. In ordering it is necessary to state the diameter, number of threads per inch, and the length of four parts, A, the reamer; B, screwed taper; C, parallel; and D, the shank. The necessity of having the thread continuous in the two plates, which are some distance apart, so that the stay bolt passes smoothly into the second plate, is the cause of the thread extending for such a length on the tap. A special form of tap (Fig. 34), made for re-tapping stay-bolt holes from the inside of locomotive fire-boxes, is known as a spindle stay-bolt tap.

The tap shown by Fig. 35 is a sort of patch-bolt tap, and is used for making a steam-tight fit. Boiler mud-plug taps are shaped as shown by Fig. 36, and are used for tapping wash-out holes in locomotives. The sizes generally range from $1\frac{1}{4}$ in. to $2\frac{1}{2}$ in. gas.

Fig. 33.—Stay-bolt Tap


Fig. 34.—Spindle Stay-bolt Tap


Fig. 35.—Patch-bolt Tap


Fig. 36.—Mud-plug Tap


Fig. 37.—Die Tap


Fig. 38.—Long Hob Tap


Fig. 39.—Short Hob Tap


Fig. 40.—Hob or Master Tap for Whitworth Gas Threads

Taps for cutting the threads on dies that are fitted in screwing heads, and where each chaser is a separate piece, are made as shown by Fig. 37. The taps are made twice the depth of thread over size, to give relief to the back of the chasers, and have helical grooves in order to prevent a jerky movement when cutting.

When it is necessary to re-cut solid or adjustable dies it is usual to employ a long and short master tap or hob. For threading out a die blank the long hob tap (Fig. 38) is used to cut the threads, and the short tap (Fig. 39) is used to finish the thread to size. Whitworth gas threads are cut in split dies by means of a master tap (Fig. 40), which is made the whole depth of one thread over standard size, and will cut in either direction.

CUTTING SCREW THREADS IN THE LATHE

The Ratio Principle.—When an accurate screw is desired it is usual to cut it

in the lathe. Screws cannot be accurately cut by means of dies, although for ordinary commercial use die-cut screws are good enough. As a lathe-cut thread is more or less a copy of the leading screw, it follows that any inaccuracies in the latter will be reproduced in the former. English lathes are usually fitted with a leading screw of two threads per inch (or $\frac{1}{2}$-in. pitch), and upplied with a set of twenty-two change wheels rising by five teeth, the smallest having twenty and the largest 120 teeth; the set always includes either two forty-tooth gears or two sixty-tooth gears for cutting screws of the same pitch as the leading screw. In some small lathes leading screws with four threads per inch are fitted. The number of teeth in lathe wheels usually rises from 15 in regular increments of 5 up to 100, and from 100 to 120 or 150 in regular increments of 10.

In many of the American lathes the leading screw has four or six threads per inch, and the change gears have teeth arranged in multiples of four. The method of calculating change wheels is exactly the same for both British and American lathes. Examples of working out change wheels for both English and American lathes will be given in this section.

In the operation of screw-cutting in a lathe the slide-rest and saddle are moved along by means of the leading screw, and the tool, attached to the slide-rest, moves with it. The rate at which the slide-rest and the tool move is governed by the change wheels that are fitted on the lathe spindle and on the leading screw. A split nut is fitted on the saddle, which can be opened or closed at any period of the traverse by the movement of a handle; the closing of the nut causes it to engage with the leading screw, and as a consequence, the saddle is moved along when the leading screw is revolving. The distance that the saddle travels for one revolution of the work spindle is equal to the pitch of the thread being cut. Conversely, if a leading screw has two threads per inch, its pitch is $\frac{1}{2}$ in., and the saddle moves $\frac{1}{2}$ in. for every revolution of the leading screw. If the work between the lathe centres revolves once while the leading screw turns once, it is evident that the tool will move forward $\frac{1}{2}$ in., and the resulting thread will have a pitch of $\frac{1}{2}$ in.; in other words, the number of threads per inch cut in the work will be exactly equal to the number of threads per inch on the leading screw, in this case two. If the lathe spindle (and hence the work) revolves four times as fast as the leading screw, the resulting screw will have four times as many threads in a given distance as the leading screw. For example, if the leading screw has two threads per inch, and a length of 1 in. has been screwed with the work revolving four times as fast as the leading screw, then the finished screw will have $4 \times 2 = 8$ threads per inch and a pitch of $\frac{1}{8}$ in. If the lathe spindle turns one-half as fast as the leading screw, it follows that the leading screw revolves twice while the work turns once. In this case, the result is that on the finished work the distance between any two adjacent threads will be twice as great as the length between two threads on the leading screw; this means, if the leading screw has two threads per inch, that the pitch of the resulting screw will be 1 in., and there will be one thread per inch of length.

It is obvious that means must be provided for causing the lathe spindle to revolve faster or slower than the leading screw. The speed depends upon the screw to be cut—that is, on whether it has a greater or less number of threads per inch than the leading screw. The variations in speed are obtained by placing a certain number of gears (known as change gears) on the lathe to connect up the spindle and the leading screw, the gears meshing into each other. When there is only one change of speed between the lathe spindle and the leading screw, the series of gears is a simple train; but when there is more than one change of speed, the train is a compound one. It is usual to employ a compound train when the ratio between the leading screw and the screw to be cut extends beyond the limits of an ordinary, or standard,

series of change wheels, or beyond the gear-carrying capacity of the lathe.

Determining the Ratio.—Before the change wheels for any particular job can be found, it is necessary to determine the ratio between the lead of the screw to be cut and the lead of the leading screw. Write them down thus:

$$\frac{\text{Lead of screw to be cut}}{\text{Lead of leading screw}} = \frac{\text{drivers}}{\text{driven}}$$

Or, if desired, the ratio may be expressed thus:

$$\frac{\text{Threads per inch of the leading screw}}{\text{Threads per inch of required screw}} = \frac{\text{drivers}}{\text{driven}}$$

When lead is used for the numerator, lead must be used for the denominator; and when threads per inch are used for the numerator, threads per inch must be used for the denominator. The ratio obtained by either of these formulæ gives the ratio between the driver and driven gears. The following examples make the matter plain. The number of threads per inch of the leading screw is assumed to be 2, and the pitch or lead $\frac{1}{2}$ in.

(1) Find the ratio for a screw of $\frac{5}{8}$-in. lead.

$$\text{Ratio} = \frac{\frac{5}{8}}{\frac{1}{2}} = \frac{5}{8} \times \frac{2}{1} = \frac{10}{8} = \frac{5}{4}$$

(2) Find the ratio for a screw of $1\frac{1}{4}$-in. lead.

$$\text{Ratio} = \frac{1\frac{1}{4}}{\frac{1}{2}} = \frac{\frac{5}{4}}{\frac{1}{2}} = \frac{5}{4} \times \frac{2}{1} = \frac{10}{4} = \frac{5}{2}$$

(3) Find the ratio for a screw of $\frac{1}{4}$-in. lead.

$$\text{Ratio} = \frac{\frac{1}{4}}{\frac{1}{2}} = \frac{1}{4} \times \frac{2}{1} = \frac{2}{4} = \frac{1}{2}$$

(4) Find the ratio for a screw of $2\frac{1}{2}$-in. lead.

$$\text{Ratio} = \frac{2\frac{1}{2}}{\frac{1}{2}} = \frac{\frac{5}{2}}{\frac{1}{2}} = \frac{5}{2} \times \frac{2}{1} = \frac{10}{2} = \frac{5}{1}$$

If the number of threads per inch of the required screw is given, it should be converted into lead. For example:

(5) Find the ratio for a screw having fourteen threads per inch, the leading screw having two threads per inch. Ratio $= \frac{2}{14} = \frac{1}{7}$, which equals the lead.

Calculating Simple Trains of Change Gears.—In the following examples of working ut change gears, unless otherwise stated the leading screw is assumed to have two threads per inch, or $\frac{1}{2}$-in. pitch.

It is desired to cut a screw having five threads per inch. Form a fraction whose numerator shall be the number of threads per inch on the leading screw, and whose denominator shall be the number of threads per inch required to be cut. Following this rule, the fraction $\frac{2}{5}$ is obtained. Multiplying both terms of this fraction by 10, $\frac{2 \times 10}{5 \times 10} = \frac{20}{50}$ is obtained, these being the necessary change wheels.

As already explained, the pitch or lead of the screw can be substituted for the number of threads per inch. Thus it is desired to cut a thread of $\frac{3}{8}$-in. pitch. To find the ratio, $\frac{\frac{3}{8}}{\frac{1}{2}} = \frac{3}{8} \times \frac{2}{1} = \frac{6}{8} = \frac{3}{4}$. Multiplying both terms of this fraction by 15, $\frac{3}{4} \times \frac{15}{15} = \frac{45}{60}$, the 45 gear being the driver, and the 60 gear the driven.

Again, it is desired to cut a thread having six threads per inch. The ratio is $\frac{2}{6}$, and multiplying both terms of this fraction by 10, $\frac{2}{6} \times \frac{10}{10} = \frac{20}{60}$, which are the necessary change whee s.

In the foregoing examples, which are for simple trains, the distance between the driver and the driven gears may be made up by two even intermediate gears or any single wheel that will properly mesh. Here it may be mentioned that having found the ratio, note should be taken whether the screw to be cut is to have a left- or right-hand thread, and whether it is finer or coarser than the pitch of the leading screw. If the required screw is to have a right-hand thread, the leading screw, which is always right-handed, must revolve in the same direction as the work. This means that the cut is taken in the direction from the tailstock to the headstock. When a left-hand thread is wanted, the leading screw must turn in the opposite direction to the work, and in this case the cut is taken from the headstock to the tailstock. If tumbler wheels are fitted at the back end of the headstock, the leading screw may be

reversed by the simple movement of a lever, otherwise a change gear, of the same number of teeth as the driven gear on the leading screw, must be interposed between the latter and the last driver.

Calculating Compound Trains of Change Wheels.—Compound trains are generally used for cutting screws with more than twelve threads per inch and for screws having a lead of more than $1\frac{1}{8}$ in. Suppose that a required screw is to have twenty-four threads per inch, the ratio is $\frac{2}{24}$; and consequently, if a single train were used, the wheel on the lathe spindle would have to revolve twelve times to one turn of the leading screw. To do this, a 240-wheel would have to be fixed on the lead-screw, and a 20-tooth gear on the lathe spindle. This is an impracticable drive; and apart from this, the set of change wheels does not include a wheel having 240 teeth. To find the necessary gears, then, proceed as follows: $\frac{20}{240} = \frac{2}{6} \times \frac{10}{40}$. Multiplying both terms of the first fraction by 10, $\frac{2}{6} \times \frac{10}{10} = \frac{20}{60}$; and multiplying both terms of the second fraction by 3, $\frac{10}{40} \times \frac{3}{3} = \frac{30}{120}$. The change gears are therefore: $\frac{\text{drivers } 20 \times 30}{\text{driven } 60 \times 120}$. The 20 gear is the first driving wheel, the 60 wheel is a driven wheel on the quadrant stud, the 30 wheel is a driver wheel on the quadrant stud, and the 120 wheel is fixed on the lead screw.

Committing to memory the rule first given and now repeated, no difficulty arises in working out any combination of change wheels:

$$\frac{\text{Lead of screw to be cut}}{\text{Lead of leading screw}} = \frac{\text{drivers}}{\text{driven}}$$

It is desired to cut a screw having twenty-seven threads per inch on an American lathe with a leading screw having six threads per inch. The change wheels being arranged in multiples of 4, the ratio is $\frac{6}{27} = \frac{2}{9} = \frac{2 \times 1}{3 \times 3}$. Multiplying both terms of the first fraction by 12, $\frac{2 \times 12}{3 \times 12}, \frac{24}{36}$ is obtained; these are the first driver and first driven gears. Multiplying both terms of the second fraction by 20, $\frac{1 \times 20}{3 \times 20}, \frac{20}{60}$ are the remaining gears. The 24 gear is placed on the mandrel, and is the driver; the 36 gear is placed on the quadrant stud, and is driven by the 24 gear; and the 20 gear is fitted on the quadrant stud, is driven by the 24 gear, and itself drives the 60 gear, which is fixed on the leading screw.

Proving Change-wheel Calculations.—In order to avoid errors, it is good practice to prove the correctness of the change-wheel calculations. There are two ways in which this can be done:

(1) $\frac{\text{Driver gears multiplied together}}{\text{Driven gears multiplied together}} \times$ pitch of leading screw $=$ lead of screw to be cut.

(2) $\frac{\text{Driven gears multiplied together}}{\text{Driver gears multiplied together}} \times$ number of threads per inch of leading screw $=$ number of threads to be cut.

Taking, for example, the change gears worked out for cutting twenty-four threads per inch, $\frac{\text{driven gears}}{\text{driver gears}} = \frac{60 \times 120}{20 \times 30} = 12$, and $12 \times 2 = 24 =$ number of threads to be cut. Taking the change wheels given for cutting a thread having a pitch of $\frac{3}{8}$ in., $\frac{\text{driver}}{\text{driven}} = \frac{45}{60} = \frac{3}{4}$ and $\frac{3}{4} \times \frac{1}{2} = \frac{3}{8}$ in. lead.

To prove the correctness of the change gears given for cutting twenty-seven threads per inch on an American lathe having a lead screw with six threads per inch, $\frac{\text{driven gears}}{\text{driver gears}} = \frac{36}{24} \times \frac{60}{20} = \frac{9}{2}, \frac{9}{2} \times \frac{6}{1}$ $= \frac{54}{2} = 27$ threads per inch.

Cutting External Threads.—Hand chasers (Fig. 41) are frequently used for brasswork and sometimes for iron and steel. They are held by hand on the T-rest. It is sometimes found necessary to cut a thread roughly with a single-pointed tool before using a chaser; but some operators are sufficiently skilled to "strike" a thread correctly on the bare material. Much of the screwed work on

brass fittings for engines, boilers, etc., is done by means of hand chasers.

Single-pointed screw-cutting tools (Figs. 42 and 43) are generally used for roughing out threads. They are held in the tool post of the slide-rest. It would be impossible to finish a standard Whitworth thread correctly with such a tool, as it cuts in the groove only, and not on the top of the thread.

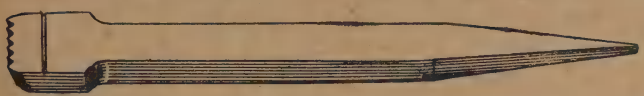


Fig. 41.—Hand Chaser for External Threads

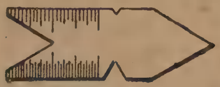
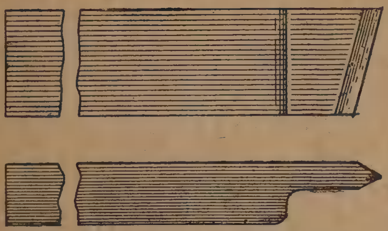
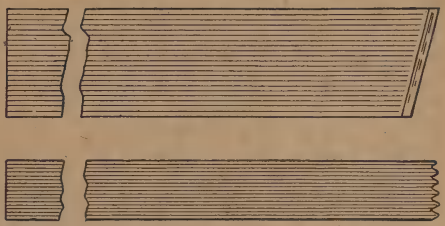


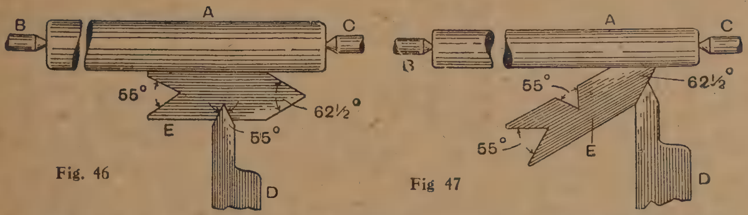
Fig. 48.—Screw-cutting Gauge



Figs. 42 and 43.—Elevation and Plan of Single-pointed Threading Tool



Figs. 44 and 45.—Elevation and Plan of Multiple-pointed Threading Tool



Figs. 46 and 47.—Alternative Methods of Setting Single-pointed Tool

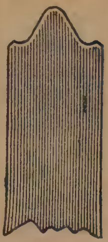


Fig. 49.—Tool for Finishing Whitworth Thread

The multiple-pointed threading tool (Figs. 44 and 45) has of late come into regular use for finishing work in two or three cuts; as in the case of the hand chaser, this form of tool will completely finish the thread. In motor works, etc., where much cast and malleable iron is screwed, these tools are in great demand. They also, of course, are held in the slide-rest tool post.

The use of hand chasers is almost entirely a matter of skill and experience, and but little useful information can be given here on the subject. The hand chaser is held down upon a piece of iron which is held in the tool-rest, and it is moved along by means of the hands, one hand holding the tool near to the front edge, and the other hand grasping the handle. In some cases, however, the operator grasps the handle with both hands; but this is only done when a thread has previously been cut with a single-pointed tool. The cutting of screws in the "self-acting" lathe, however, while calling for a certain amount of skill, is more a matter of following a certain definite procedure, for which instructions are here given.

The ordinary single-pointed screw-cutting tool should be clamped in the tool post as close to the point as possible in order to prevent springing. When the tool first begins to cut, only one cutting

edge is at work for a short time; for this reason the end thread should be rounded off before testing with a gauge nut for size. It frequently happens that the screw is of incorrect size at its beginning, owing to the spring of the tool. Lack of clearance of the side of the cutting edge will produce an incorrect thread, as will also incorrect height of the tool.

A single-pointed tool is set in the manner shown by Fig. 46, in which A is the work, B and C the lathe centres, D the tool, and E the setting gauge. This gauge (Fig. 48) consists of a piece of thin sheet steel pointed at one end, notched at the other, and notched on the sides; some gauges have the edges graduated in parts of an inch. The angle of the pointed end is $62\frac{1}{2}°$, since half of 55° (the angle of the Whitworth thread) is $27\frac{1}{2}°$, and this subtracted from 90° gives $62\frac{1}{2}°$; this can be better understood by referring to Fig. 47, which shows the pointed end of the gauge in use for setting the tool, and in which the same letter references as in Fig. 46 are used.

Whitworth threads cannot be finished by means of a single-pointed tool of the type shown in Figs. 42 and 43, as it would leave the top and bottom of the thread angular instead of rounded. A tool of this class could be used for cutting the sharp or **V**-thread, as is sometimes used in the United States; but in this case the angle would have to be 60° instead of 55°, and a corresponding alteration would have to be made in the setting gauge.

A single-pointed tool for finishing a Whitworth thread must be shaped as shown in Fig. 49. This form of tool is expensive to make, as it is correctly formed by means of a special cutter of a costly type, and it is not much used in up-to-date practice. When sharpening this tool it is ground on the top face only in order that its shape is not altered.

Generally, a Whitworth thread is roughed out with an ordinary pointed tool, and then finished with a chaser. The height of the tool should be such that the cutting edge is exactly on the same horizontal line as the lathe centre. Assuming that the tool is correctly ground to an angle of 55°, this position will give an accurate result; if a single-pointed tool is placed above or below the centre of the work, the thread will be incorrectly shaped.

When using multiple-pointed tools, the cutting edge is set exactly level with the centre of the work. A square is often used for correctly setting the tool in the horizontal position, as indicated in Fig. 50, in which A is the work, B the live centre, C the dead centre, D the cutting tool, E the square, and F the tool post. In making this form of tool, the teeth are cut at right angles with the shank; hence if a square is used to set the tool as illustrated, a correctly shaped thread is obtained.

Cutting Internal Threads.—Hand chasers (Fig. 51) are greatly used for making internal threads on brasswork; they have the same advantage of finishing the thread as have external hand chasers. Sometimes a fine thread is cut by means of a single-pointed tool, and the thread finally brought to size by means of the chaser. The chasing by hand of an inside thread is more difficult than external threads.

Single-pointed inside screw-cutting tools (Fig. 52) are often used, but they have the same disadvantage as single-pointed tools for external threads—that is, they cannot finish the thread. They are ground to an angle of 55°, and tested in the setting gauge as indicated in Fig. 53. The relative positions of tool and gauge are of importance; the point of the tool must be ground in such a manner that the shank is parallel with the length of the gauge, as shown, because if the point is ground in the position shown in Fig. 54, the two cannot be used, for the shank will foul the back edge of the hole when the point is in the correct position for working, even though the point is correctly ground for shape. Fig. 55 indicates the position in which such a tool would have to be placed, and it is obvious that the shank of the tool would prevent any work being done.

When setting a single-pointed tool for

internal screw-cutting, the method indicated by Fig. 56 can be adopted. The screw-cutting gauge A is held against the face of the work B, and the tool C fastened in the tool post or slide-rest, so that the point fits the gauge as shown. If desired, the alternative method shown by Fig. 57 can be used; the side of the gauge A is held on the face of the work B, and the tool C adjusted so that one side of the point touches one angle of the gauge. If this method of setting is adopted, care must be taken that the tool point is correctly ground to shape.

Inside threads can be completely finished by means of circular chasers of the form shown in Figs. 58 and 59. Such chasers are fixed in a holder which is

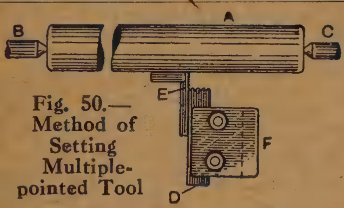


Fig. 50.—Method of Setting Multiple-pointed Tool

Fig. 51.—Hand Chaser for Internal Threads

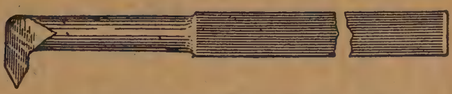


Fig. 52.—Single-pointed Internal Tool

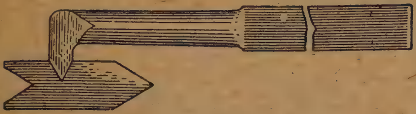
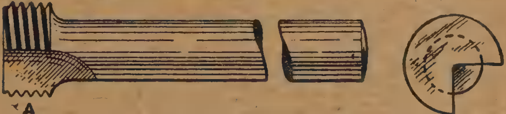


Fig. 53.—Testing Internal Tool



Figs. 58 and 59.—Circular Chaser

Fig. 54.—Incorrectly ground Internal Tool

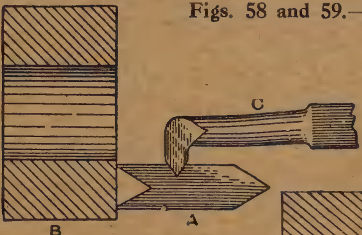


Fig. 56.—Method of Setting Inside Tool

Fig. 55.—Position Necessitated by Incorrectly ground Internal Tool

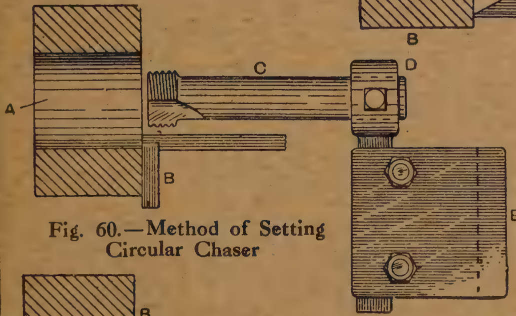


Fig. 60.—Method of Setting Circular Chaser

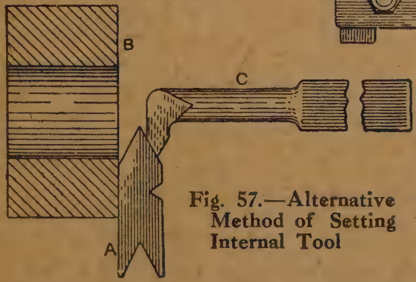


Fig. 57.—Alternative Method of Setting Internal Tool

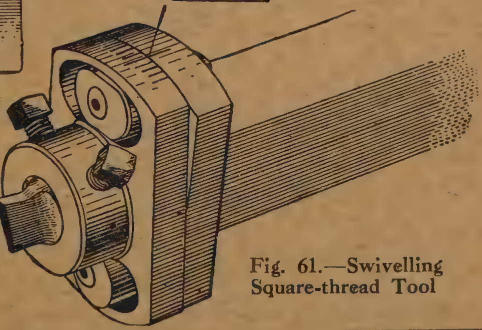


Fig. 61.—Swivelling Square-thread Tool

clamped in the tool-rest, and they are set in the correct position by means of a square, as in Fig. 60, A being the work held in a chuck, B the square, C the chaser, D the holder, and E the tool-rest. The shank of the tool C is set parallel with the blade of the square B, and as the cutting edges of the tool are formed parallel with the shank, it follows that correctly shaped threads will be produced. The cutting edge of the chaser should be placed on the centre of the work. A point in favour of circular internal chasers is that the cutting edge A (Fig. 58) can be repeatedly sharpened without altering the shape.

Removing the Tool for Grinding.—It is often convenient before removing the tool for grinding to note carefully the groove in which the point is cutting, to draw out the tool by means of the cross slide screw, and stop the machine, still keeping the nut in mesh with the leading screw. Now, if, after grinding, the tool is replaced in exactly the same position as it previously occupied, all will be well. Some mechanics, however, prefer to move the saddle back to the starting point, remove the tool without noticing its position, and afterwards replace it in the tool-rest, using the setting gauge to ensure the tool being square with the thread. When a tool is reset in this manner, it frequently happens that upon engaging the nut with the leading screw, the point of the tool is not in correct relation with the groove that had previously been cut. It is usual in cases like this to take out of gear one of the change wheels, and turn the leading screw gear round until the tool moves along with the saddle into its correct position; while this is being done the nut is, of course, engaged with the leading screw, and, when the exact position has been obtained, the gears are again placed in mesh and the feed-nut disengaged.

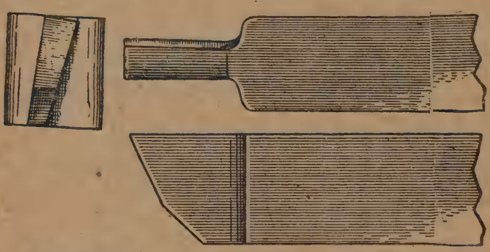


Fig. 62.—Tool for Cutting Square Threads

Disengaging the Feed Nut.—When cutting an odd number of threads per inch, or a number that is not exactly divisible by the number of threads per inch of the leading screw, it is important that the nut is engaged exactly at the same place. If, however, the lathe is fitted with a reverse motion, the saddle can be brought back to the starting point without disengaging the nut. In cases where no reverse motion is fitted, the tail-stock can be clamped to the bed, and a piece of iron bar or other suitable material laid across the bed, so that the saddle is prevented from going past the tail-stock; with the saddle up against the bar, the lever that closes the nut should be operated, and if it is easily manipulated a chalk mark should be made on the top of the leading screw, and also on the top of the faceplate or on the top of the chuck. When again engaging the nut, the saddle must be brought back to the starting point, and the lever manipulated when the chalk marks are in the same position as when starting. When cutting a screw with an even number of threads per inch, or a number that is divisible by the threads per inch of the leading screw, the feed nut can be engaged at any time and when the saddle is in any position.

Cutting Square Threads.—When cutting square threads, a tool (see Fig. 62) similar to a cutting-off tool is used, but with a different angle of side rake for every pitch and diameter of screw. If it is desired to cut a square thread having four threads per inch, the tool would be $\frac{1}{8}$ in. wide, since the space and thread together would equal $\frac{1}{4}$ in.—that is, the space is $\frac{1}{8}$ in. wide, as is also the thread. A novel tool (Fig. 61), which obviates the difficulty of making different tools for each pitch and diameter of thread, has been found quite satisfactory. It consists of a shank, which is clamped in the tool post, and which has a swivelling head fitted with the cutting tool. The tool is securely held by means of the two

screws shown, and the head can be swivelled after releasing the nuts at the back of the flange. The top of the moving head is graduated at A, so that the tool can quickly be set to the required angle.

Cutting Double and Triple Threads.—In the cutting of a double thread, first one thread is cut in the usual manner until the uncut material between the grooves is equal to the width of the thread already cut. The change gears are then disengaged, and the lathe spindle, along with the work, is given half a turn. The gears are then intermeshed, and the second thread cut. When cutting triple threads, the work is given a third of a revolution, and in the case of quadruple threads, a quarter of a revolution.

CUTTING SCREW-THREADS ON WOOD

Wood-screwing Taps.—Wood-screwing taps and screw-boxes of different sizes for cutting handscrews, knob-screws, etc., form part of the general wood-turner's outfit. Ordinary taps for tapping threads in metal may be used for tapping female threads in wooden chucks for the lathe, but the pitch of thread is much too fine for many wood screws, and metal-screwing dies are practically useless for cutting the male threads on wood. Fig. 63 shows the simple form of fluted steel tap for wood-screwing, four or five of the bottom threads being tapered off to nothing as at A, to permit free entrance of the tap into the hole, the flutes being three or four in number, as shown in cross section in Fig. 64. Such taps operate by scraping. The style of tapered tap illustrated by Fig. 63 will only cut full threads in "through-going" holes, which permit the tap to pass right through, as is evident from a study of the illustration.

Fig. 65 illustrates the form of steel tap for cutting screws in wood, it working equally well in either end-grain or side-grain stuff. The threads in this tap are finished parallel, three or four threads being sufficient; this also tends to reduce the frictional resistance in screw-cutting. The tap is easily made with the aid of a screw-cutting lathe, but can also be turned up and the screw-thread hand-chased with a chaser of suitable pitch. The tap is finished as shown, the top end A being turned the size to suit the diameter of the tapping hole, and drilled hollow to form a free escape for the waste cuttings which are cut out by the screw itself. A hole is drilled through to the escape hole B, and the inside of the hole filed out to a cutting edge as indicated at C (Fig. 65).

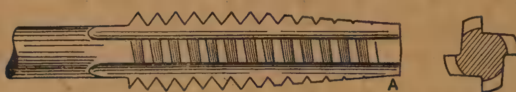
Making Screw-boxes.—The action of the tap in cutting the female thread in making the screw-box or other internal screwing is shown in section (Fig. 66), in which A, B, C indicate the parts shown in Fig. 65, and D the block of wood which is being threaded; the screw is cut by fixing the tap vertically in the bench-vice, gripping the square tang D (Fig. 65), and starting the thread by pressing the block of wood with both hands firmly down to the cutter, at the same time twisting it with both hands towards the left until the screw "bites."

Boxwood is the best wearing wood for making the screw-box, but, failing it, dry, seasoned beech will do very well; the pieces required are one 5 in. long by $1\frac{3}{8}$ in. thick and $2\frac{1}{4}$ in. wide (for $\frac{5}{8}$-in. diameter screws, and, of course, wider in proportion for larger screws) for the box, and one piece the same width and length and about $\frac{1}{2}$ in. thick for the cover. The longitudinal section (Fig. 67) shows how the pieces forming the screw-box are dressed and dowel-jointed loosely together with tapered wooden pins A, so as to separate easily when the cutter is to be sharpened, etc.; the hole is also bored in this way. The hole through the cover B is bored with a centre-bit the size to suit the outside diameter of the screw, then the hole C is bored tapping size, with the centre-bit point guiding in the impression left by the point of bit in previous boring. The parts are next separated, and the tap run through the box, preparatory to cutting out the cutter bed and the gab for escape of the cuttings.

Figs. 68 and 69 show a side elevation and section of the cutter (which is prepared in the same way as the beading-plane cutters, Figs. 35 and 36, p. 151, Vol. III), it

being bedded into the screw-box, so that the heel A is in alignment with the outside thread, as shown at A (Fig. 70), in which position it is adjusted to working order and fixed with the kneed-bolt B, the gab being cut out as indicated at C, and also in Fig. 71. The kneed-bolt is shown by Fig. 72, and as it projects above the cutter a countersinking is prepared in the cover to permit the box closing together.

A screw-box with turned handles is shown in Fig. 73. It is made in the same way as the other, but with the additional length at the ends for turning the handles, plus the waste piece A for cutting off at the prong-chuck end; and in this case, instead of tapered wooden dowels, the cover is secured for turning with snap-headed screw-nails B. In turning the handles, the centres for prong and poppet-



Figs. 63 and 64.—Ordinary Fluted Tap for Wood

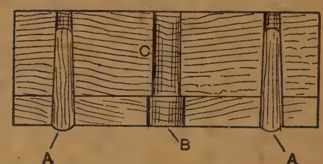


Fig. 67.—Horizontal Section of Screw-box

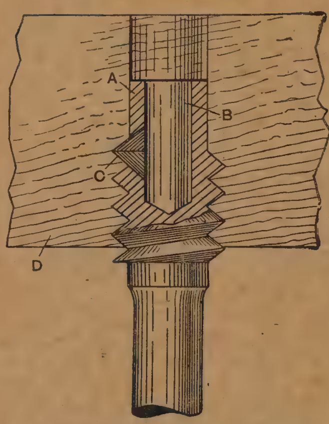


Fig. 66.—Cutting Internal Threads

Fig. 72.—Kneed Bolt

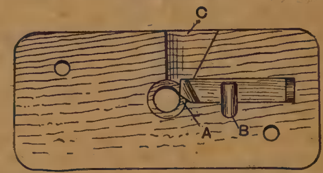


Fig. 70.—Screw-box with Cover Removed

Fig. 71.—Plan of Screw-box

Figs. 68 and 69.—Cutter.

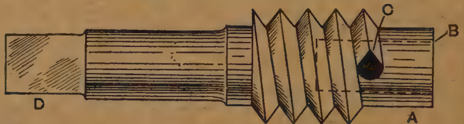


Fig. 65.—Tap for Cutting Screws in Either End Grain or Side Grain

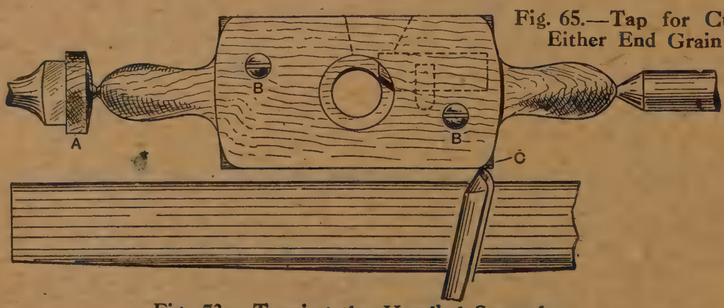


Fig. 73.—Turning the Handled Screw-box

Fig. 74.—End View of the Screw-box shown in Fig. 73

chucking are not taken coincident to the square end of the screw-box, but they coincide with the centre of the box as at A (Fig. 74), the screw-box being thereby thrown off the centre to the extent of the thickness of the cover, the angular corners of which are turned off smoothly with the box, the turning gouge being held at the angle shown at C (Fig. 73).

These screw-boxes with guidance of the cover are well adapted for cutting long screws which do not necessitate the thread being cut full to a square shoulder, as is often the case for short screws. Although the makeshift of removing the screw-box cover could be adopted for running the thread to a shoulder, it is much better to use the screw-box specially made for cutting shouldered threads.

Figs. 75 and 76 show front view and section of screw-box for cutting threads close up to a shoulder. To obviate undue wearing of the gab a metal plate, prepared from an ordinary iron washer of suitable diameter, is sunk flush to the face of the screw-box and fixed with countersunk screw-nails as at A. This screw-box is coverless and therefore without guidance other than the workman's hands; thus it requires to be carefully held with the hand at right angles to the work when starting the thread, using considerable pressure at the same time to make the thread "bite"; this kind of screwing is mostly done whilst the work is in the lathe chuck, so that the screws may be cut to length and the job finished at one operation. Fig. 77 shows an example of how the pin is turned for screwing; it is chamfered at A for starting the thread, and at B to let the screw cut clean out to the shoulder, so that the screw butt joints together as indicated in Fig. 78, which shows a turned pillar, A, screwed into a base, B.

The pins are, of course, in every case turned to the full diameter of the screw that is required.

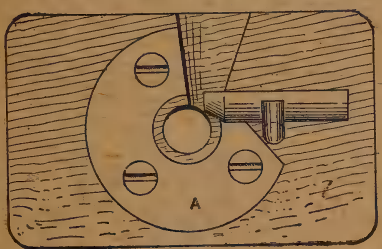


Fig. 75

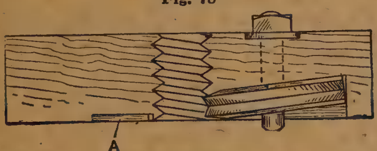


Fig. 76

Figs. 75 and 76.—Screw-box for Short Screws

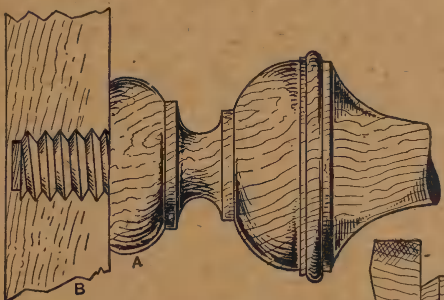


Fig. 78.—Screwed Joint

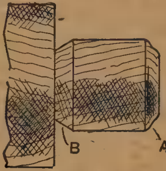


Fig. 77.—Turned Pin for Screwing

Renovating Old-fashioned Mirrors

A Mantel Mirror.—An old-fashioned mantel mirror, shown by Fig. 5, p. 248, is in bad condition. Originally the frames were gilded, and very handsome they look when restored to that condition. Re-gilding, however, is expensive, but considering the time that real gold-leaf gilding lasts it might be regarded as economical. It is not often that the owner of such a mirror as the one here shown is willing to go to the expense of re-gilding—partly because of the cost and partly because gilt-work is supposed to be "out of fashion." Gilding is recommended only when it will go well with its surroundings. In this case, the gold had become shabby, and had been painted a dull grey, but the colour was unsuitable, the work indifferently done, and no attempt had been made at repairing the carving, the pieces being simply stuck up in place. It is now decided to have it properly repaired and finished in ivory-white enamel, which will go well in a bedroom papered in an art shade of blue, and containing enamelled furniture.

Fig. 1.—Repaired Carving

Fig. 2.—Enamelling the Carved Portions

The first thing to do is to take off the rest of the carving, then remove the backing and the glass to a safe place. The frame and pieces of carvings are next washed with hot water containing a little soda, rinsed off with clean water, and dried.

The carved work for the top of the frame has been made in four parts to fix together, and is put on with screws through the frame from the back. There are two

parts shown still in position on the frame in Fig. 5, the other parts being broken. The part for the left of the centre is

Fig. 3.—Carvings Removed from Mantel Mirror

broken at A (Fig. 3); this is a splintery break, recently done, and fits together quite neatly, so it only requires to be carefully glued and strengthened by gluing a bit of canvas across at the back. The topmost part is broken at B, and the broken surfaces need to be carefully scraped clean and tried together, then glued and strengthened as before. The breakage of the right-hand corner ornament is treated in the same way, but there is a bit broken off and missing at D. It is easy to see from the left ornament what is required, and a pattern should be taken, marked out on a piece of postcard, placed behind it, and cut out with the point of a knife. The crooked, broken surface is trimmed straight with a sharp chisel, and the new piece cut to the pattern made to fit it, and glued after the manner of making a "rubbed" joint (see Fig. 28, p. 249, Vol. III). When set, it is trimmed to the finished shape (see Fig. 1).

All the carving and the frame are now smoothed with No. 0 glasspaper, and brushed free from dust ready for the first coat of enamel. It is proposed to give it two coats of flat enamel and two of glossy, allowing a day after each coat to dry, and smoothing down each time. For convenience in handling the frame, a lath is screwed at the back from the centre of the lower rail to the top, and the carving also may have small pieces screwed on to strengthen it.

The enamel should not be too quick-drying, so as to give freedom in brushing it on evenly. The work is best done in a warm room (free from dust),

Fig. 4.—Enamelling the Frame

and each coat should be surface dry in about three hours. After the last coat, the enamel should be allowed ample time

to harden before replacing the glass and back; then the two earplates for fixing can be screwed on at the top to be hidden

Fig. 5.—Mantel Mirror in Need of Renovation

by the carving. The finished mirror is shown by Fig. 6.

A more advanced treatment is to enamel only the frame, and to gild the carving. But, of course, there are often conditions when neither enamel nor gold would be quite suitable, it being preferred to have the frame the same colour as the furniture of the room, mostly walnut or mahogany. To do this it may be stained by dissolving aniline walnut stain (powder) in french-polish; or by using bismarck and walnut mixed for mahogany. It is best to have the stain a few shades lighter than is required, and to gain the right tone by two or more coats. The stain must be applied quickly, with as little brushing as possible, as it is very quick-drying, and two coats may be given in the course of an hour. After a little smoothing down it may have two coats of brown hard spirit varnish applied evenly with a camel-hair brush in a warm room. When dry it may be improved by stroking over lightly with a "rubber" of french-polish, which will level and harden it. This treatment is the most frequently adopted, because it is more generally suitable and is the more readily accomplished.

Renovating a Toilet Mirror.—An average example of an old-style looking-glass before and after restoration is shown by the photographs (Figs. 7 and 9) on the opposite page. One of the feet is broken off, the mirror will not keep in position owing to the "movements" being worn, the standards are loose on

Fig. 6.—Mantel Mirror Restored and Enamelled

Fig. 7.—Old-style Looking-glass in need of Repair

the base, and it is in need of touching up and repolishing. It had been in that condition for years. It was proved that a new one of much commoner make and material would cost more than double the figure that a practical cabinet-maker would charge to restore the old mahogany one.

The first thing to do is to take the mirror from the stand, and it is found that the loose standards only need the nuts of the wooden screws tightening up. To keep them from working loose again a small hollow is made in the side of the nut, and a screw inserted to fix the nut, as shown in Fig. 8, the screw being long enough to go into the standard to strengthen the joint. The foot is next glued in place and secured with a small screw.

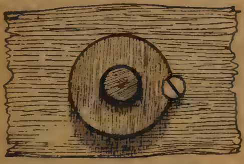


Fig. 8.—Method of Fixing Nut of Wood Screw

The mirror movements are of the old hinged kind, thumbscrew and ball. As always happens, they have worn so that the ball is not gripped tightly enough to retain the mirror in position. A simple remedy for this is to put a piece of sheet brass $\frac{3}{8}$ in. square in the hollow to fit against the ball, so that when tightened up by the thumbscrew it is pressed into shape, thus making up for what has been worn away.

The mirror and standards need to be detached for cleaning up with fine glass-paper, brushing free from dust and then repolishing. If the surface is rather faded it may be improved by staining with a little bismarck and walnut aniline stain powder in thin french-polish solution. It is allowed to rest as long as convenient, then polished with the french-polish rubber in the usual way.

On page 91 information is given on re-silvering parts of mirrors, but this is not an easy thing to do with complete success, and, in the absence of special experience in carrying through chemical processes, it is more desirable to replace the damaged mirror with new glass. It may be cheaper to send a shaped mirror to the works so that the old silvering may be cleaned off and the glass re-silvered.

Fig. 9.—Looking-glass Repaired and Repolished

Cycle-lighting Dynamos and How to Build Them

Details of the Machines.—Cycle-lighting dynamos, such as the one shown by the reproduced photograph (Fig. 1) are the simplest of all mechanical self-contained generators of electricity. The method of working is based upon the fact that when a wire is caused to pass through a magnetic field a current of electricity is induced or generated in the wire.

In order to carry out conveniently this principle, a length of wire is coiled a great many times round an iron core, and this is revolved between the poles of a horseshoe magnet, suitable means being provided for the collection of the current as will be explained later. The iron core with its coils of wire is termed the armature and the magnet the field-magnet. These parts are clearly shown in Fig. 2, in which it will be seen that the magnet consists simply of a strip of steel, suitably bent, and the armature core of three pieces of iron joined together by riveting, and provided with a shaft or spindle. In this second photograph the side plates that support the bearings are not shown, but Fig. 1 clearly shows the entire assembly.

The essential parts of another machine, slightly different in design, are shown by Fig. 3 and in this the armature, instead of being placed across the magnet, is in a longitudinal position. Fig. 4 is a diagram of the magnet N S and the armature core A with its winding. For the sake of clearness the winding is shown as consisting of only a few turns of wire, but in practice a few hundred turns are provided. The commencing end of the wire is attached to the core by soldering, and then the wire is wound on in one direction in a series of

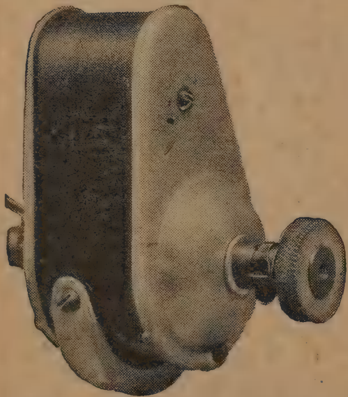


Fig. 1.—Simple Type of Cycle-lighting Dynamo

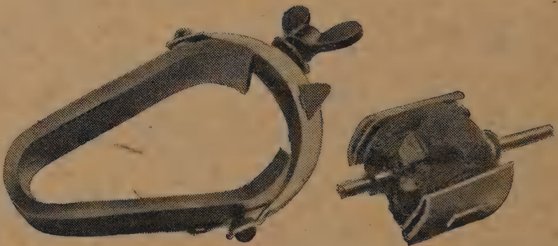


Fig. 2.—Field-magnet and Armature of Cycle-lighting Dynamo

layers, the finishing end being attached to an insulated stud or slip-ring against which a metal spring, for the collection of the current, presses. As the commencing end of the wire is attached to the armature core, the other electrical terminal is any part of the metal frame or body of the machine.

Fig. 3.—Field-magnet, Armature and Bearing-plate of Another Type of Cycle-lighting Dynamo

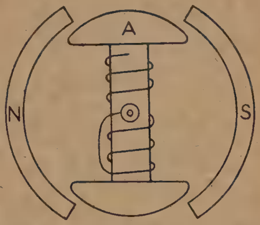


Fig. 4.—Diagram of Field-magnet and Armature showing the Armature Winding

The use of permanent magnets is almost essential for cycle-lighting dynamos, as with them the voltage is unable to rise above a certain limit whatever the speed, and consequently there is less risk of burning out the lamps such as would be the case with a machine with wound fields. In the case of car-lighting dynamos, the difficulty has been overcome by means of mechanical, electrical or magnetic governing devices ; but the use of these for cycles is out of the question on account of weight and cost.

MAKING A CYCLE-LIGHTING DYNAMO

In many of the commercially-made machines there are features, such as specially-shaped magnets, etc., that cannot very well be made by the amateur, but the cycle dynamo shown by Fig. 5 can be constructed by anyone capable of using simple metal-working tools, the object throughout having been to keep it simple, substantial, and dustproof. From its unavoidably exposed position to weather and dust a system of watertight, dustproof construction is distinctly necessary.

The Field Magnet.—An important part of any permanent-magnet dynamo is the field magnet. Unless this is strongly magnetised and of a suitable quality of steel the results will be disappointing, and for this reason the amateur is advised to purchase his magnet ready-made and magnetised, and to treat it with all possible care while building the rest of the machine. This advice applies particularly to such precautions as keeping the magnet poles bridged across by a substantial iron armature when not in use. Dropping or jarring a magnet, too, is harmful and tends to weaken it.

Ordinary cast-steel does not make good magnets, and an alloy known as "tungsten" steel is mostly used, as not only does

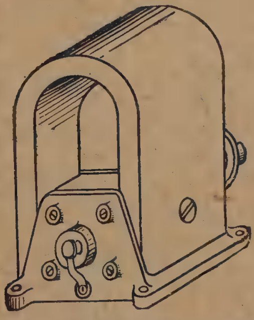


Fig. 5.—Cycle-lighting Dynamo specially designed for Building at Home

this take up a higher degree of strength, but it retains its magnetism for a longer period. This steel is difficult to forge and to drill, and the least expensive way for those unaccustomed to its peculiarities is to buy the magnet complete, as even if they succeed in shaping it up success-

fully, there is still the difficulty of giving it a proper degree of hardness which ensures its retentivity of magnetic properties. Fig. 6 gives the outline of the magnet in side and end elevation.

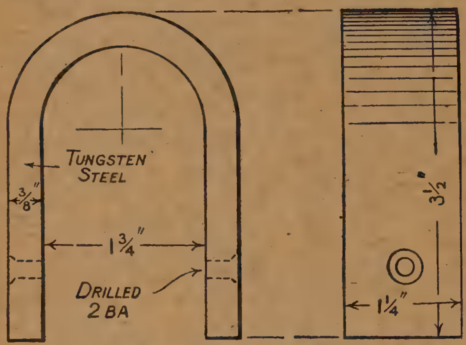


Fig. 6.—The Steel Magnet

Pole Pieces.—It is essential that the armature should run as closely to the magnet as possible, and therefore the latter requires pole-pieces fitted to the ends, as shown in Fig. 7. These need not be of magnet steel, and they are usually made of ordinary soft cast-iron, since they acquire magnetism from the proximity to the permanent-magnet poles, and lead the magnetic field into the armature where

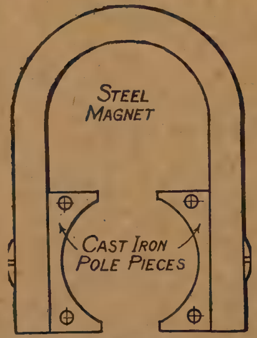


Fig. 8.—Complete Magnet with Poles Attached

it is needed. The iron castings forming the pole-pieces are shaped or faced on the flat sides until they bed nicely against the magnet limbs, and then are attached to them by means of countersunk steel screws tapped into the pole-pieces as shown.

If a lathe is available, fix the magnet and pole-pieces on the face plate in the lathe, keeping the magnet poles bridged across the ends with an iron armature, and proceed to carefully bore out the armature

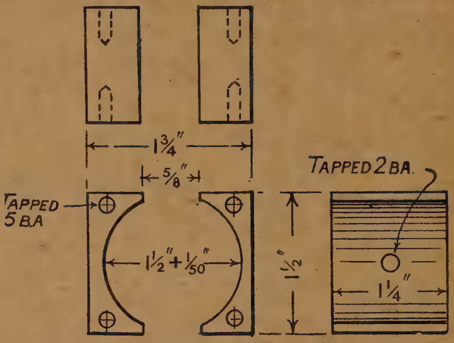


Fig. 7.—The Cast-iron Pole-pieces

tunnel to a diameter $\frac{1}{50}$ in. larger than that of the armature core itself. This leaves a clearance of only $\frac{1}{100}$ in. all round, and naturally requires nice work and much care. But it is worth securing, as the output of the machine depends largely on the important question of airgap between armature and poles. The magnet complete with pole-pieces attached is shown in Fig. 8.

It will be seen from Fig. 7 that the pole-pieces have eight other holes drilled and tapped, one in each corner, for the holding screws of the end plates carrying the bearings; but the drilling of these holes had better be left until the armature is completed, or they may not come properly in line.

Bearing Brackets. — The bearing brackets or end plates consist of aluminium castings, and are exactly alike, except that one of them has the baseplate cast on to it to save work. Details are given in Fig. 9. The central bosses are bored out to receive Hoffmann $\frac{1}{4}$-in. ball journal bearings of the light "S" type (Fig. 10), and need to be a good light driving fit on the outer ball races. The recess into which the bearings slide is shown dotted in one view of the endplates (Fig. 9). It is not usual in fixing ball journal bearings of these small sizes to employ any other

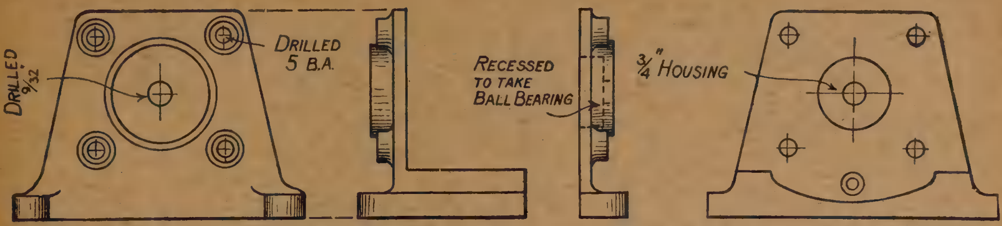


Fig. 9.—Aluminium End-brackets of Cycle-lighting Dynamo

means of holding them, either in the brackets or on the shafts, except by a "friction fit." Therefore this part of the work demands some care, as the limits between tight and loose fits are very small. Plain bearings could be used if desired, but naturally ball bearings will give better service.

The four holes in each aluminium end-plate can be drilled, and the base and ends machined up, square-fitting them to the width of the magnet and its pole-pieces already prepared. Do not, however, drill the pole-pieces until the armature has been completed, as it is necessary to insert this in the tunnel and centre it before marking for the screw-holes.

Armature and Shaft. — The armature core is a malleable iron casting shown in end and side views in Fig. 11, and has two brass caps (Figs. 12 and 13) fitted to it, one at each end, each cap carrying half the armature shaft. The caps themselves are held to the armature casting by means of small bolts or rivets passed through holes in the caps and into the recesses cast into the armature body. To ensure getting the two shafts into line a "spigot" joint is made at each end between caps and armature body, as shown in Fig. 11. The malleable casting should be first centred and then turned true to size as regards the outside diameter between lathe centres, the spigots also being formed at the same time.

The best way to build up the brass end caps to the armatures (Figs. 12 and 13) is to drill and tap the brasses, screw and rivet them firmly to the steel shafts, leaving them larger than the finished size required, and then mount them by the end of the shaft (left longer for that purpose) in a self-centering chuck, and finish all over to size without removing again. This ensures everything coming up perfectly true and concentric. The extra length can be cut off the steel shafts later, and if they are left a shade large, the journal bearings can also be made a nice fit with fine file and emery-cloth.

One steel shaft end is left solid and takes the driving pulley, while the other is bored and carries the insulated end of the armature winding in a manner to be afterwards described. This construction of armature leaves a clear space for the armature winding, as seen in the view of the assembled armature and end caps (Fig. 15).

The method of making connection between the insulated end of the winding and the metal button against which a spring collecting brush presses is shown in

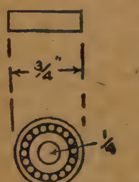


Fig. 10. — Ball Journal Bearing

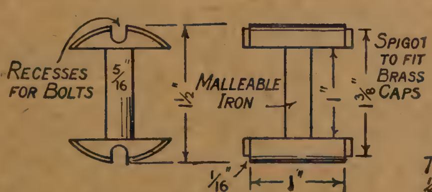


Fig. 11.—Malleable-iron Armature

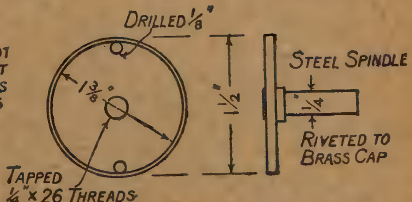


Fig. 12.—Armature Back-end Cap

the sectional view of the front bearing cap (Fig. 13). This brush is shown in Fig. 5 at the bottom of the machine. and again in detail in Fig. 14.

Fig. 13.—Armature Front-end Cap

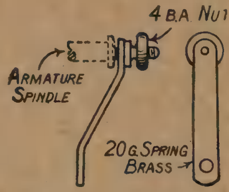


Fig. 14.—Spring Contact Brush

To make the connection drill a central hole through the steel shaft at the front cap end $\frac{5}{32}$ in. in diameter, drive tightly into it a piece of hard fibre or bone, and again drill this with a $\frac{3}{32}$-in. hole, taking every care to get the holes true, or the insulating tube thus formed will have sides of uneven thickness. Push a copper wire through the bone bush, or a large copper- or brass-headed nail, with another fibre insulating washer of $\frac{1}{32}$ in. thickness at each end, and after hammering the end of the nail flat where it comes through inside, turn it up squarely and cut it off flush with the bearing cap. It must project as little as possible inside, or it will get in the way of the winding.

Winding the Armature.—The winding of the armature is a very simple matter. Cut some presspahn sheet, $\frac{1}{50}$ in. thick, of the right size to go once round the wire channel of the malleable iron armature body, and two pieces for the flanges or cheeks. These can be fixed with seccotine or any adhesive compound for the time being. The starting end of the wire, which is No. 26 double-silk-covered copper. is given a turn round the screw-head shown in the centre of the core (Fig. 14), and the screw tightened down until the head lies flush with the casting; or an alternative method is to solder the end of the wire to the core.

The wire is then wound on with the greatest care so as not to damage the covering, and with every turn pulled tight and even, until it is seen that no more can be got on without touching the end caps. The latter are then screwed in position, and the free end of the armature wire soldered to the projecting connection which passes through the front end of the shaft, and the whole soaked in shellac varnish for an hour, and after draining, put in a warm oven for the night. If the varnish is thin. repeat this process next day.

Assembling.—To finish fitting the end flanges carrying the ball bearings, proceed as follows: Cut a piece of brown paper of even thickness and free from folds, stout enough so that when wrapped once round the armature it is just possible to push it into the pole-pieces. This locates the armature truly central, and the end flanges with their ball journal bearings in place can then be pushed on the two projecting ends of the shaft, until they bed up against the iron pole-pieces fixed to the permanent magnet. If they do not come up exactly square, the flanges must be faced anew until they do, as the slightest inaccuracy in fitting ball bearings will give rise to trouble. It will facilitate matters here if, when boring the pole-pieces, the end faces projecting just through the magnet are also squared off in the lathe.

The aluminium flanges also can be faced when the recesses for the journals are formed at one setting in the lathe; it is then impossible for the flanges to come

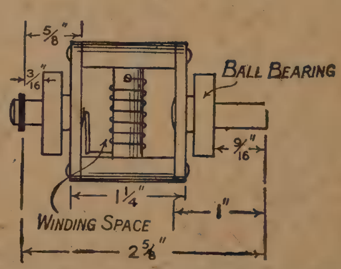


Fig. 15.—Armature of Cycle-lighting Dynamo, showing Winding and also Attachment to Insulated Contact

up out of truth. When this has been arranged to satisfaction, scribe the positions for the four holding screws in the corner of the pole-pieces, these holes

having already been drilled in the aluminium flanges. Drill and tap to drawing sizes, and the flanges can be finally screwed on. The armature should spin quite freely when the permanent magnet has been temporarily removed. When it is replaced, of course, the iron armature

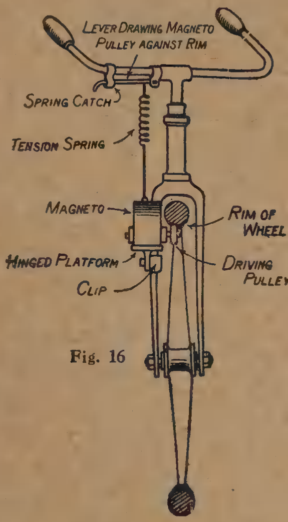


Fig. 16

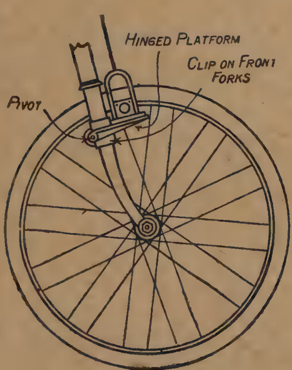


Fig. 17.

Figs. 16 and 17.—The Dynamo Mounted on Bicycle

cheeks will be strongly attracted by the magnetism of the pole-pieces, and it will run jerkily and tend to stop in two definite positions only, where the armature iron comes next to the poles.

The spring brush shown in Fig. 14 now remains to be fitted. This is of hard spring brass or copper held by a single screw to the aluminium flange in front, from which it is insulated by means of fibre or bone washers and a bush. The end of the spring, where the shaft centre bears, is carefully set out and drilled for a 4 B.A. brass screw terminating the other side in a nut for connection to the outer circuit. The head of the screw is slightly hollowed to drop into the centre of the convex button; or, better still, a copper-carbon washer inserted between the two. A metal or fibre cover is needed to close in the gap existing between the tops of the aluminium end flanges and the armature rotating beneath, and this may be attached with small screws to the edges of the aluminium.

Attachment to the Cycle. — The driving arrangements will vary so widely, according to the style of machine to which this dynamo is attached, that definite instructions are impossible to cover each and every case. As a general rule, friction drives are not altogether satisfactory, because if driven off the rim the latter is seldom true enough to ensure steady running, unless there is excessive pressure between rim and pulley. From the tyre this objection is largely absent, but there is then a question of carrying all road dust and dirt directly on to the magneto, which is not altogether desirable.

One or the other of these alternatives cannot be avoided on a pedal cycle, and it lies with the rider to decide whether he prefers back- or front-wheel drive. Mounted on a hinged fixing, the friction pulley can be easily arranged to draw on and off the tyre or rim by means of a Bowden wire and lever on the handle-bars. Another suggestion is given in Figs. 16 and 17. For motor cycles, a separate belt rim and the magneto fixed on a platform and driven by a belt will probably be the best solution.

The machine as described will light one 6-volt 6-c.p. headlamp, or one 4-volt headlamp and one 2-volt rear light in series, each taking about 1 ampere.

Metal Spinning

THERE are few mechanical processes less understood by the amateur than that known as metal spinning; but why this is so is not easily understood. While he is not to be expected to produce spun work with the same degree of accuracy and finish as can a professional, there is still no reason, provided he owns a fairly stiff, high-speed lathe, why he should not turn out very creditable work of the kind.

It is the present intention to treat upon the subject of metal spinning wholly from an amateur's point of view, having regard to the equipment and tools which the average metal worker is likely to possess.

The Art of Spinning Explained.—The spinning of metal consists in the conversion of flat sheet metal into objects spherical or curved in shape, without having to resort to either cutting, piecing, or fitting. Whatever variation is brought about in the thickness of the metal is caused by the metal being either compressed or stretched, as the case may be.

In forming the common domestic hollow circular articles by means of dies, they are pressed to shape between a male and female tool; but there are limitations to which operations of this character can be carried, as, for instance, in complete spherical objects, or what might be termed incurved, in which the male part of the die cannot be withdrawn after forming. This is where the art of spinning has such an advantage over press-tool work. To make a pair of dies may be a very costly undertaking, and dozens of articles might be spun in less time and at a quarter the cost of producing the dies necessary to do the job.

The products of metal spinning are used in a great many lines of manufacture. Examples of this work are electric and gas fittings, cooking utensils, silver and britannia hollow ware, automobile fittings, bedstead ornaments, etc. The photograph, Fig. 1, represents a group of spun articles, in various kinds of metal, and among them will be recognised a copper ball of a cistern valve, a copper lamp top, a couple of brass bedstead ornaments, a fancy aluminium box with hinged cover, and one or two brass fittings used in the production of gas and electric light brackets.

The Lathe.—The act of spinning involves considerable stress on the lathe mandrel, since the strains are often wholly in a transverse direction to the axis of the spindle. Therefore the spindle must be sufficiently strong and rigid to resist these strains, and shake, bearing slackness, and lateral play must be absent. Speed, too, is an important factor, and if the lathe is not geared sufficiently high to meet the speed demands of the various metals the result will be far from satisfactory.

Arbitrary rules for spinning speeds are difficult to give, since the thicker the metal being operated upon the slower must be the speed. For example, iron $\frac{1}{32}$ in. thick can be readily spun at 600

revolutions per minute, whilst for double this thickness the speed would not exceed 400 revolutions. Zinc spins best at 1,200 revolutions per minute; copper, brass, aluminium, and britannia metal at from 800 to 1,000; whilst iron and soft steel can be spun at a speed as low as 400 revolutions per minute. A reversing lathe is unnecessary. A typical lathe for spinning is shown by Fig. 2.

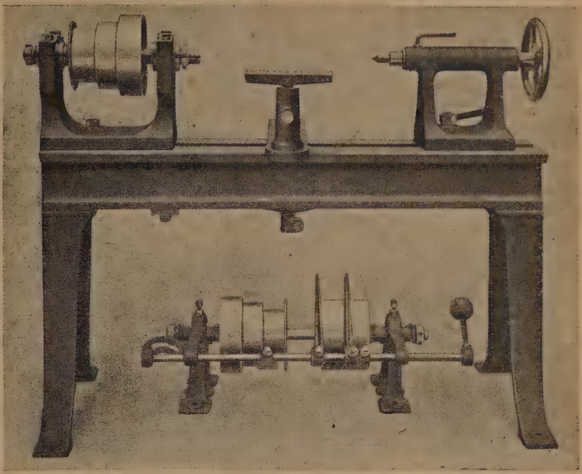


Fig. 2.—Metal-spinner's Lathe

The **T**-rest is essential; it should be adjustable both up and down, and towards or from the centre in the usual way; but instead of the ordinary form of tool-rest used for either wood or iron turning it should be of the shape shown by Fig. 3 and at least 8 in. long, 1 in. wide, and $\frac{1}{2}$ in. thick. Its upper face should be pierced with closely spaced holes of about $\frac{5}{16}$ in. diameter to receive two movable pegs, $\frac{3}{8}$ in. in diameter, shouldered down to fit easily in the holes, and project above the face of the **T**-rest about 2 in. These pegs provide a fulcrum against which the tools press whilst being manipulated on the work.

The ordinary back-centre attached to the lathe may be used by the amateur, but the spinner will find that a non-friction, rotatable centre (Fig. 4) is almost indispensable; it does not cost much to make, and will repay the time and trouble expended thereon, simply by reducing friction, and so causing the lathe to run more sweetly. The centre consists of a parallel piece of steel, about $\frac{1}{2}$ in. in diameter, sliding within a sleeve, the end of which fits the tailstock in the usual way. The pressure is taken by the steel ball interposed between the faced and hardened end of the centre proper and the bottom end of the sleeve,

Fig. 1.—Group of Objects Spun in Metal

any pressure being brought to bear against the end of the centre tending to revolve it.

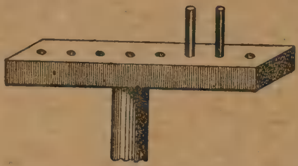


Fig. 3.—Tee-rest with Fulcrum Pegs

Another type of centre is the revolving ball-bearing centre (Fig. 5), which, if required, should be purchased, as its cost is not excessive.

Other useful accessories are the screwed male and female centres (Fig. 6), which are almost essential when split formers are used.

The Spinning Tools.—The amateur should obtain his tools as his skill and requirements grow, because as he gets more accustomed to the work, and his attempts become less elementary experience will teach him just what tools he will need for his purpose. To start with, he will require a selection from the group shown by Fig. 7, which he might make himself from old files or discarded hand-turning tools; but for spinning much longer handles will be needed than are required for hand turning. The handles should be at least 18 in. long, or, in other words, long enough to enable them to be gripped comfortably under the worker's right armpit. This is to ensure strength and leverage, as spinning demands all the worker's arm strength and muscle.

If the amateur decides to make the tools himself, and his material happens

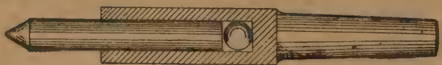


Fig. 4.—Revolving Back-centre

to be worn-out round files, it will be best, first of all, to anneal them thoroughly throughout their length, then to grind the teeth marks completely out, as otherwise they will, when in use, grip the rest—an undesirable feature—and the marks might start cracks during the subsequent hardening. They can be forged roughly to shape, filed up, finishing with the smoothest of files and the finest emery-cloth, and then hardened to maximum hardness, after which they should be polished with crocus powder or flour emery on a piece of buff leather, until a deep black finish is attained.

In the group shown by Fig. 7 A is a rest used in conjunction with the ordinary T-rest, and in which the spinning tool is supported whilst doing an awkwardly shaped job where it is found necessary to use the tool inside the work. B and C are tools used for beading over the edges of the work. D is the fish-tail or flaring

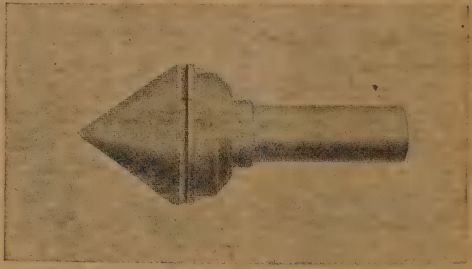


Fig. 5.—Ball-bearing Revolving Back-centre

tool and is used for smoothing over already roughed-down work. E and F are round-nosed or ball-ended, tools for breaking down curves or flanges. G is a flat planisher or smoother; H is a skimmer; I, J, and K are tools used mostly for internal spinning, or for flaring out curves, etc. Those which an amateur will be likely to require for his initial experiments may comprise D, E, F, G, and K. As he grows familiar with their use experience will teach him what others to make, and how best to shape them.

The Choice of Metals.—Iron, mild steel, brass, copper, britannia metal, or even gold and silver may be spun. In choosing one of these materials for a first attempt, the first two, iron and steel, had best be put out of court at once as being too difficult for a learner to work, as well as requiring more strength and skill

than he will at first possess. Brass may easily be operated upon, but even this in the hands of the inexpert will most probably crack. Copper lends itself best to

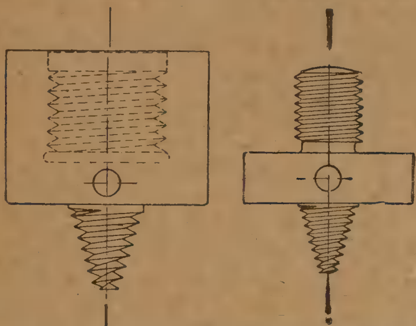


Fig. 6.—Internal and External Threaded Centres

the beginner's efforts, as it is both tenacious and ductile, and will stand much more abuse than will any of the other metals. It might be supposed that the thinner the metal the more readily it will assume the shape desired; but this is a mistake. If the metal is too thin, instead of compressing in section, as will be needed at times upon pressure being applied through the tool, a buckle results, and all the amateur's labour cannot then remove it. For the purpose of the example about to be described, sheet copper of about 18 B.W.G. (·049 in. thick) would be best. This must be well annealed before using by heating it to a dull red heat and allowing to cool.

An Example of Spinning.—Now let it be assumed that the beginner is to spin up an object in shape similar to that shown in section by Fig. 8, this being considered a fairly simple example, and one that brings into use a typical forming chuck, together with some outside formers, adapters, or followers, which should illustrate the general principles involved in many of the operations connected with plain spinning. Set out the object full size on paper, and then in thin zinc, etc., make a half template of the contour, and with this (or the sheet from which the half template was cut) as a guide turn up

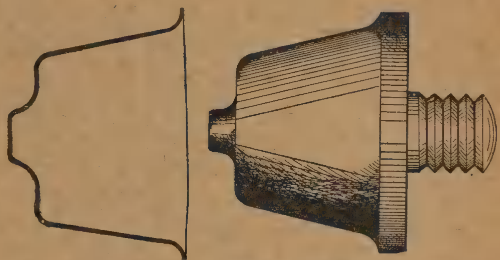


Fig. 8 Fig. 9

Figs. 8 and 9.—Spun Metal Object and its Former

the wood former upon which the metal has to be spun. The former should be of some hardwood, such as beech, box or maple of even density, and free from knots or cracks (in the trade, metal formers are often used). First rough turn the former

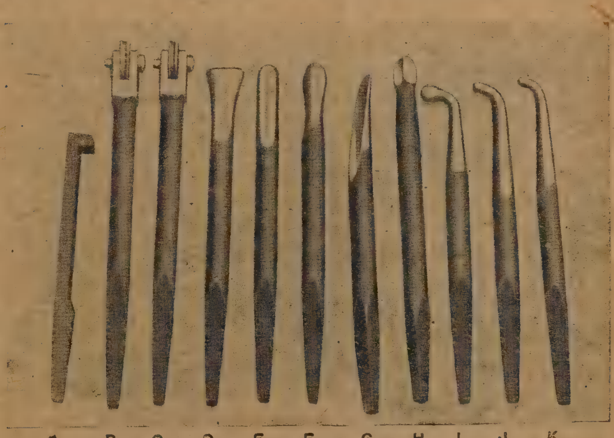


Fig. 7.—Group of Metal-spinner's Tools

to approximate dimensions, but finish off the end which either screw into, or is a plug fit into, the nose of the lathe mandrel. Finishing the business end of the wood former must be done with it in situ, in order that it shall run dead true

with the lathe. The outer diameters of the former will, of course, coincide with the internal diameters of the spun object. A finished former, adapted to screw into the nose of the lathe mandrel, is shown by Fig. 9.

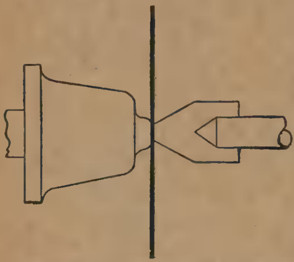


Fig. 10.—Former, Disc and Adapter in Position

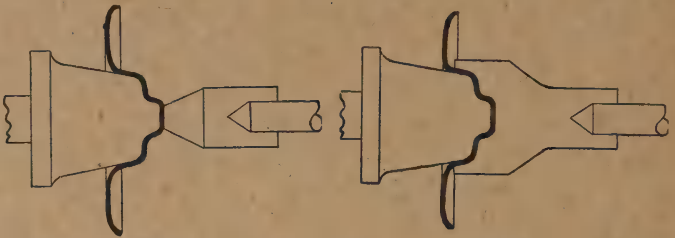


Fig. 11

Fig. 12

Figs. 11 and 12.—First and Second Stages of Spinning

Now cut out a disc of copper of such a size that it will be sufficient to extend when spun to the extreme end of the former. This may be arrived at approximately by measuring with a piece of fine twine from the centre of the former, following along the curves to the end of the flange, and taking this dimension as the radius of a circle; but, as will be explained later, any superfluous metal around the edge will require cutting off before the final spinning stage is reached.

In the example given it will be noticed that the object has a small flat end; therefore, in this case it will be an advantage to use what is known as a centre adapter in conjunction with the rotating centre already described. It may take the form of a piece of hardwood which slips over the end of the steel centre, turned down at the end quite flat, and of such a diameter that it is a little less than the diameter of the flat part of the object being spun. The copper disc is scribed with a circle equal to the diameter of the adapter in order to localise it accurately; the disc is then held against the latter, the centre with the adapter on it run up and pressed sufficiently tight against the disc to hold it in position whilst running. This arrangement ready for operation is shown by Fig. 10. The T-rest is now set up just to miss the periphery of the copper disc, and the two pegs inserted in the holes most convenient for manipulating the tool.

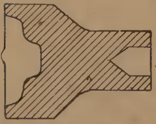


Fig. 13.—The Follower

Before proceeding, however, there are yet two provisions to make. First, the face of the disc being operated upon requires to be smeared with soft soap or vaseline in order to reduce the friction and consequent heating; secondly, what is known as a "back stick" must be called into requisition. This is a short piece of round hardwood, in length and size not unlike an ordinary ebony desk ruler—in fact, such a ruler answers admirably. This is to be held in the left hand, and in use is pressed fairly hard against the side of the disc opposite to that upon which the spinning tool is operating; it reduces the liability of the metal to buckle.

Holding the Tool.—Everything being in order, and the lathe running, take up the ball and point tool, grasping it firmly under the right armpit, and the steel end between the pins of the T-rest. Set the nose of the tool a little below the centre, and, at a point towards the worker, apply pressure and start to bring the tool outwards towards the periphery of the disc, constantly repeating the stroke, but applying little pressure on the return. Do not allow the tool to rest in one position with the pressure applied, otherwise

the metal will unduly stretch at this point; and always let the back stick follow as closely as possible the operating tool. Remember that the pin in the T-rest is the fulcrum against which the tool must press, the worker's body and arm supplying the necessary leverage. Do not be disheartened if, after a few such strokes of the tool, the disc is found to be badly buckled at the edge; this is inevitable with a beginner.

When the spinning has reached the stage shown by Fig. 11, it will be as well to remove the work from the lathe and re-anneal it, for it is surprising how hard it will become in the process.

The Finishing Stages.—Before re-starting the actual spinning, the amateur should provide himself with a follower (Fig. 13), something like an adapter, made of hardwood, and attached to the back-centre. Its purpose is to support and hold that part of the disc already spun, and to keep it securely in place, whilst the remaining part of the operation is being carried through. As fixed for a resumption of the operation, with the follower in position, the job will appear as in Fig. 12.

It now remains to complete the flange end of the shell. Resume operations with the ball and point tools in order to break the flange down, afterwards finishing with the planisher. As the outer edge of the shell is reached, it will doubtless be found that there is a superfluity of metal over and above that required to complete the edge of the flange, and that the flange refuses to conform tightly to the shape of the wood former, its tendency being to spring away. It is a good plan before trimming off the edges, and in order to insure a snug fit of the shell on the wood former, to remove it from the lathe and again anneal it, then, when again in position, to proceed to turn off the superfluous metal from the edge with an ordinary diamond-point hand-turning tool; after which, flare the flange down to the former. In the trade, little or nothing would now require to be done in the matter of finishing; but an amateur will almost certainly find in his example numerous ridges and high places, and perhaps hollows, which have escaped the planishing tool. These must be carefully gone over again with the finishing or burnishing tool, and if they still refuse to become amenable they must be removed, or at least reduced, by the application of a smooth file and emery cloth.

Fig. 14.—A Spun Object for which a Sectional Chuck would be Necessary

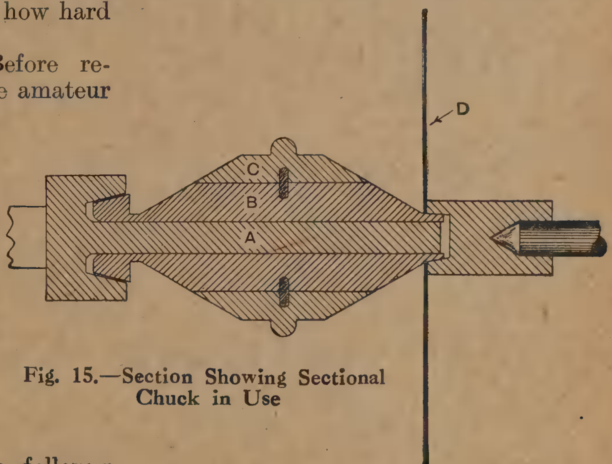


Fig. 15.—Section Showing Sectional Chuck in Use

Sectional Chucks. — The foregoing example embraces a simple operation, involving nothing difficult or complicated in the matter of equipment, it being a perfectly simple job which, when finished, comes away from the wood former with ease. But there are numerous jobs in which chucks have to be made of special shape so that they may be withdrawn from the interior of the finished incurved work. Take, for instance, the example of spun work shown by Fig. 14. If the former used in this case were similar to the one

already described, and the work spun over it, there would be no means of removing it except by cutting or burning it out. When such objects as these have to be spun, it is usual to employ what is known as sectional chucks or formers, these being chucks or formers built up in sections and capable of being afterwards removed piece by piece.

The principles underlying most sectional chucks are embodied in the chuck shown by Fig. 15. In this, A is the body of the chuck adapted either to fit the nose of the mandrel, or else screwed to fit one of the chucks illustrated in Fig. 6, and made with a parallel extension piece the length of the chuck and integral with the body. The members B and C may be any convenient number, made first as a whole, then slit down into sections small enough to permit withdrawal through the end hole in the finished work. These fit at either end into slightly tapered recesses, one into the chuck body at the lathe mandrel end, and the other into a follower adapted to fit the tailstock centre. The outer members C may be joined to B by loose dowels if so desired. Upon pressure being brought to bear from the back-centre, the whole of the chuck will be gripped tightly together; the disc D to be spun is provided with a hole and slipped over the chuck end before assembling, as shown. Upon completion of the operation, the chuck extension piece A is pulled through the members B and C, these being afterwards drawn singly through the end hole in the work.

Taking Paper Casts from Moulds

THE following instructions apply to the taking of paper casts from concave moulds (made of plaster-of-paris), especial attention being directed to the method of preventing excessive shrinkage.

The moulds should first be saturated with linseed oil to prevent absorption, or the paper will not leave them readily when required; the oil will also toughen the plaster. If the relief is low, that is, if there are no marked irregularities of surface in the moulds, such as will be likely to break a piece of damp paper, it may be best to use the paper in sheets or convenient strips. The inside of the mould must be greased.

The paper should be unglazed, porous, and only moderately thick. The first layer should only be damped on that side which is to go against the mould with a sponge and clean water; it should then be laid on the pasteboard and its other side brushed over with paste. A small quantity of Russian glue should be boiled in the paste to give greater strength, and the paste should be used hot. The clean side of the paper is laid in the mould, and it is pressed down so as to make it bend into every hollow—dabbing with the end of a stiffish brush will drive it home where required. The next, and every succeeding layer of paper, will be coated on both sides with hot paste, and will have to be pressed down well in place. Air bubbles and creases are to be guarded against. This work is repeated until the required thickness is gained, but at about every fourth layer it will be necessary to dry the work in a warm place.

After it has been freed from the mould, it is the practice of papier-maché workers to make their work more firm by giving it a bath of linseed oil. By this method the shrinkage will be very small. If, owing to the nature of the moulds, this plan is impracticable, paper pulp should be well mixed with the glue-paste, and after being squeezed fairly dry, should be forced into every indentation of the greased mould, and as much pressure should be put on it as the mould will bear. By this plan the shrinkage will be slightly greater.

Building a Model Racing Yacht

The Design.—For the sake of an example in model yacht building a model "10-rater" designed under the "length and sail area rule" has been chosen, as this is simple and easy to build to, produces a fast boat, and is much used. Fig. 1 shows two 10-raters starting on a race on the Round Pond at Kensington, London. The hull lines are given in detail in Fig. 2 and the body plan in Fig. 3 (one-third full-size). The rating rule for 10-raters is ascertained by the following formula: $\frac{L \times SA}{6{,}000} = 10$; where L is the length on the load-water-line with the boat fully rigged, and S A the sail area in square inches. These two factors when multiplied together and divided by 6,000 must not exceed 10. The design provides a load-water-line length of 40 in. and a sail area of 1,500, consequently it works out as follows: $\frac{40 \times 1{,}500}{6{,}000} = 10.$ These dimensions give a long boat, which must be very light in the hull, while an allowance of 1,500 sq. in. of sail should be quite adequate to drive the hull at its maximum speed.

The "Lines."—For the actual work of building the hull only a few "lines" are essential, but in the actual designing many more lines than those shown in Fig. 2 are needed to get a fair form. To grasp the meaning of the "lines" start by studying the load-water-line L.W.L. This line represents the shape of a horizontal plane passing through the hull at the same level as that of the water in which the boat is floating. The hull is always drawn

Fig. 1.—The Model 10-rater Yacht taking part in a Race

as if it were floating quite level and in stagnant water. Other water-lines are shown at w1, w2, w3, w4 and w5. These are horizontal water-lines, and parallel to the load-water-line L.W.L. (also marked w3 in Fig. 2). The shapes of these water planes are the shape that the water would

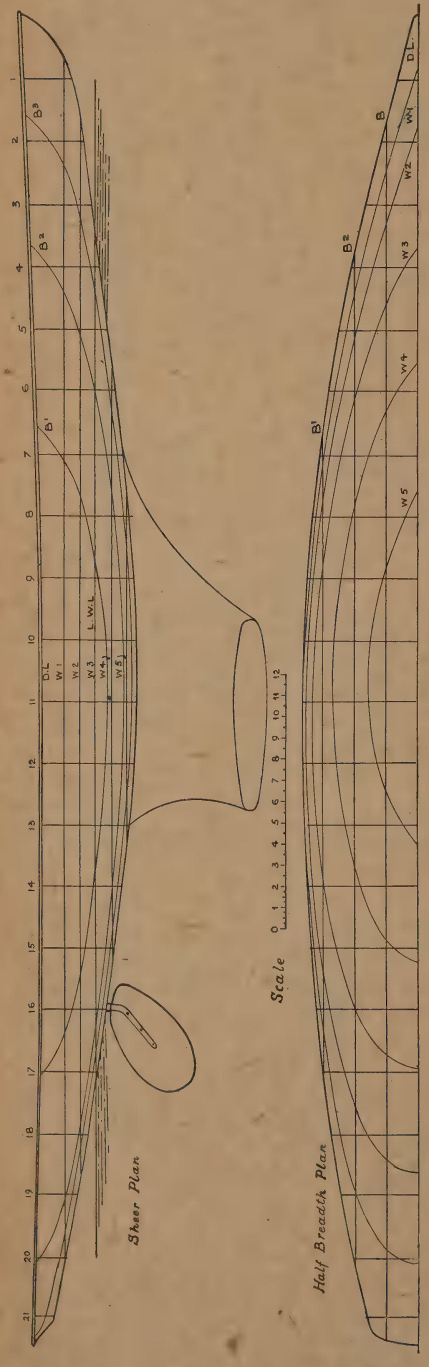


Fig. 2.—Lines of the Model 10-rater Racing Yacht

take if the hull were floating in water at the depths marked, or in other words, would be the shape of the top of a hole in a block of ice if the water were to be frozen with the hull in it and the hull subsequently lifted out.

The profile of the boat, or its outline as shown on the sheer plan, is the shape of the boat on a vertical plane, through the fore and aft centre line. The deck line D L is the horizontal shape of the deck, shown on the half-breadth plan, and the "sheer" or curved shape of the hull side where the deck meets it. The half-breadth plan shows only one-half of the hull from the centre line, as, of course, both sides of the hull are or should be alike. The body plan lines numbered W1 to W5 correspond with those similarly marked on the sheer and half-breadth plans. The curved or section lines numbered 1 to 21 are cross-sections at right angles to the centre line of the boat, and perpendicular through it. They represent the shape of the hull as it would appear if it were to be sawn asunder on any one of those sections. For example, the section No. 6 on the body plan is the shape of the hull at station No. 6 on the sheer and half-breadth plans.

The body plan is generally the most useful to work to when building the hull. The buttock lines B^1, B^2 and B^3 are the shape of a longitudinal and perpendicular plane that is parallel with the longitudinal centre line of the hull, but is taken some distance out from the centre. For example, the buttock B^1 on the sheer plan is the shape of the hull as it would appear if it were sawn through along the straight line B^1 on the half-breadth plan. The buttock lines are also shown on the body plan, and wherever a buttock line cuts a water-line on the sheer and half-breadth plans it must correspond with those positions on the body plan, otherwise the hull form will not be fair. Indeed, this is the real reason for drawing these numerous sections at different planes in the hull—to ascertain that the hull form is true and fair, free from bumps or hollows, and that the sections themselves are true to their desired shape. Diagonal lines and curves of sectional areas are also taken out when

designing the hull, but are not reproduced on the hull drawings.

The effect of altering the shape of, say, section No. 5 on the body plan would therefore require corresponding alterations in the buttocks and water-lines, and shows how difficult it is to modify the lines of a design without ruining it. Therefore, if a set of lines for a boat is to be built to, it is imperative to adhere to them rather than to try to shorten or lengthen them, or make any other alteration. Those given in Fig. 2 are thoroughly typical of a modern boat.

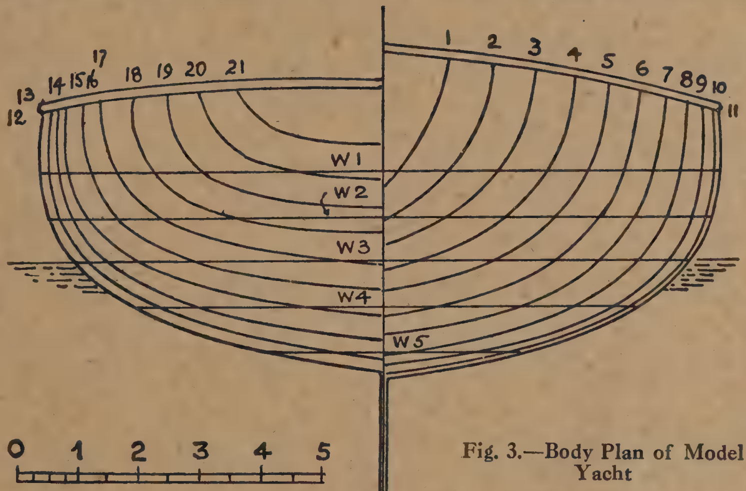


Fig. 3.—Body Plan of Model Yacht

Building the Hull.—The hull can be built in many different ways and from numerous different materials. It can be made from a solid block of pine hollowed out. It can be made on the "bread-and-butter" system by using several layers or flat boards, each of which is cut externally to the shape of a water-line, and as much material cut out of the centre of the board as possible. These layers are then fastened together with glue, dowels, and finally stitched with copper wire after the hull has been shaped. But for a workmanlike job resembling the real thing there is nothing to beat the regular shipwright's method of rib-and-plank construction on the carvel or flush-joint system.

This system will be adopted in the present case. The general lines of procedure are to mount on a strong baseboard a set of moulds corresponding to the sections on the body plan; to fix a keel, stem and stern piece on them, also the bent ribs, and to fit and fix the planks to the ribs, afterwards removing the hull from the building board and finally decking it over and completing it.

The baseboard may be a nice straight piece of deal about 3 in. wide and 2 in. thick, nicely planed up square, and take care to see that it is straight.

The Moulds.—The moulds can be cut from $\frac{3}{8}$-in. thick wood; the smaller sections can be solid, and the larger ones built up from several pieces. The external shape of the moulds are to be those which are given on the body plan above, less an allowance for the thickness of the planking and the ribs, in this case $\frac{1}{8}$ in. for the planks and $\frac{1}{8}$ in. for the ribs. When marking out the moulds draw a centre line, also the L.W.L., at right angles to it, and make the length from the L.W.L. to the bottom of the mould the same on every mould, so that when they are all standing upright the load-water-lines will all coincide.

As the boat will be built bottom up-

wards the "bottom" of the mould will be the "top" or deck part of the hull, and it is necessary that the length of the mould from the L.W.L. to the bottom is such that the hull when planked will be above the level of the baseboard. A suitable length for the 10-rater moulds is $7\frac{1}{2}$ in. from the L.W.L. to the bottom. When all the moulds have been cut they are to be checked into the baseboard for a depth of $\frac{1}{4}$ in., and the centre line of each mould must be on the centre line of the baseboard. The result so far will now appear as in Fig. 5. Now test the moulds for accuracy, and see that the load-water-lines on the moulds are all level and the centre line is really straight and true. Any inaccuracy in form of the moulds will be reproduced in the finished hull.

to be cut to accommodate the planking. Afterwards the inner part of the block is to be hollowed out as much as possible. A rebate is to be cut along each side of the keel as shown at E, leaving a parallel portion $\frac{1}{4}$ in. wide in the centre. The rebate should conform to the curvature of the hull, and is continued right along to the stem and up it to the deck level. Now cut notches in the centre of all the moulds for the keel piece to fit into, as shown at A in Fig. 5. The keel piece is to sink into the moulds until its upper edge (as the moulds stand) is $\frac{1}{4}$ in. above the edge of the mould. If all is correct the rebates on the keel will now be $\frac{1}{8}$ in. above the mould, but will conform to their general lines. This is shown in Fig. 4, where A is a mould, B the keel, C the rebate.

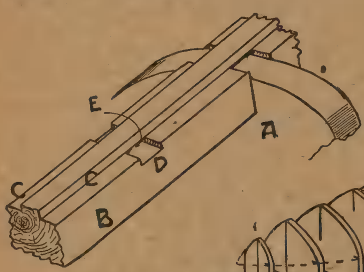


Fig. 4.—
Details of the Keel

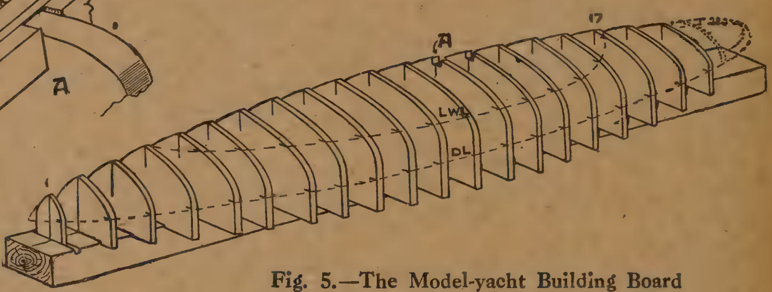


Fig. 5.—The Model-yacht Building Board

The Keel.—The next thing is to prepare the keel, stem and stern posts and to fix them to the moulds. The keel (Fig. 6) should be sawn to shape from good sound mahogany, either in one piece or preferably built up with sound scarved joints from two or three pieces (see A and B, Fig. 6).

The keel should be $\frac{3}{4}$ in. wide and an average of 1 in. deep. It should be shaped with chisel, gouge, spokeshave and plane to the proper profile, as shown in Fig. 2.

Now cut the stern block or fashion piece C (Fig. 6) from good sound mahogany and shape it accurately to the external shape as given by the body plan (Fig. 3). It extends from midway between sections 19 and 20 to the stern. It is to be checked on to the keel piece, glued, dowelled and screwed to ensure a sound joint, as shown in Fig. 5. The rebate D, $\frac{1}{8}$ in. deep, is then

The Ribs.—These should be of elm; oak or mahogany can be used. The ribs should be $\frac{1}{8}$ in. thick and $\frac{3}{8}$ in. wide. To secure the ribs to the keel cut notches or joggles E (Fig. 4) in the keel, into which the ribs can fit. Those for sections No. 7 to the stern, being nearly flat, can be pierced right through the keel; but the bow sections will have to be cut separately from each side of the keel. As the ribs are inside the hull or under the plank, it is necessary to cut little grooves across the rebated portion of the keel to ensure them finishing up flat and flush with the rebate, as shown at D. Before cutting these notches the stern block should be blocked up to its proper height, with a packing piece between the under side of the stern block and the baseboard. The stem should be blocked up in a similar manner,

and the keel held in place in the moulds by means of a few panel pins partly driven home so that they can easily be withdrawn.

Now prepare the fin by cutting it to the shape shown in Fig. 6, and make it from $\frac{1}{8}$ in. thick oak with the grain vertical. Cut slots through the keel for the two legs to pass through, and a groove $\frac{1}{4}$ in. deep between them to accommodate the fin.

The next item is the bending and fitting of the ribs. They should be cut to length, and as far as possible should be fitted in one piece from gunwale to gunwale. They should be glued and pinned to the keel, using brass pins, and fastened at the bottom with a screw into the mould, a sufficient length being left on the ribs to allow of this, as after the planking is fitted these projecting parts can be cut off. Some of the ribs may need steaming or sponging with boiling hot water to render them pliable enough to lie flat on the moulds. Fix all the ribs in the same way and leave the job to set for a day, after which the planking can be taken in hand.

Testing the Ribs and Framing.—The planking of the hull is probably the most difficult part of the work; it must be well done or the boat will leak. The planks must also "run" without undue twisting or straining, otherwise the hull will be distorted. Before starting the planking it is desirable to be quite sure that the ribs and framing generally are quite fair and true. Test the alignment of the L.W.L. by means of a straightedge blocked up to the correct level and temporarily held in place with clamps. The straightedge should be vertical or perpendicular, and a set-square applied from the back of this to the side of the moulds should show that the L.W.L. lines marked on each mould are in line or level. If they are not the moulds must be carefully adjusted until all is correct.

The next procedure is to obtain a splining batten and test the ribs for correct curvature longitudinally. It will be found that the ribs will need a little bevelling on the forward sides of the forward sections and on the after sides of those abaft the midship sections Nos. 11 and 12. This is remedied by means of a cabinet

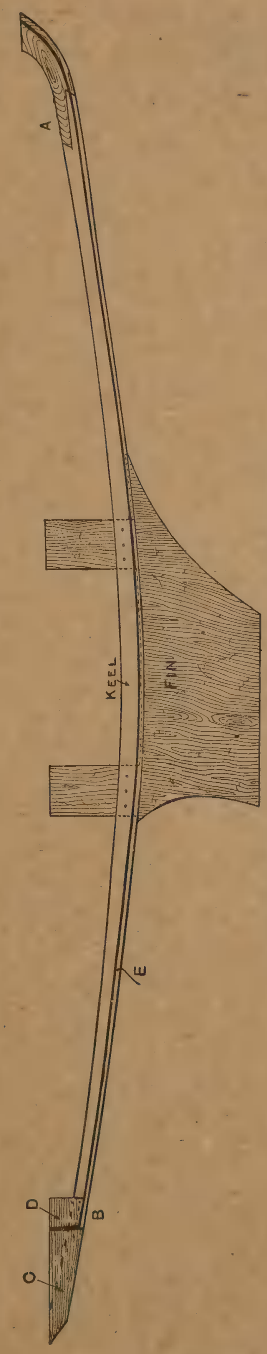


Fig. 6.—Keel and Fin of the 10-rater Model Yacht

rasp, the object being to ensure that the planking will lie flat and snug on the ribs and not be strained in any way.

Brief consideration shows that if a strip of flat wood, say 1 in. wide, be laid along the ribs of the boat, it will not lie

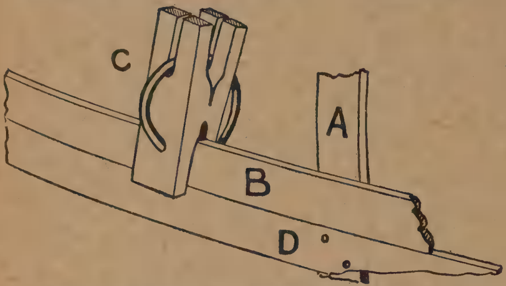


Fig. 7.—Methods of Cramping a Plank in Position

flat unless it is able to follow the curvature of the hull in a natural manner. Try such a strip, and it will curve upwards or downwards according to the form of the hull. Therefore to get the planks to fit nicely into place they must be shaped. They are seldom, if ever, parallel strips. The shaping, or variation in breadth of the plank, must be such that with but few exceptions each plank is continuous from end to end of the hull, wider in the middle and tapering away towards the stem and stern.

The lower planks below the bilge, forming the "floor," are somewhat differently shaped, and the lowest of all terminate at the rebate on the keel piece. They must work into the rebate easily, and of course nothing in the way of odd tapered bits to fill up with can be tolerated. The whole success of the hull depends on this shaping of the plank, and it must have every attention.

Finding Plank Shapes.—A cheap and practical way of finding out how the planks are shaped is to use cardboard strips and cut them to fit, pinning them temporarily in place to the ribs. Another good method is to divide the distance round the rim or edge of the rib on the midship section, from the edge of the garboard strake (dealt with later on) to the top of the gunwale or under side of the deck, into as many equal spaces as there are to be planks, say eleven or twelve, and to divide similarly each section into the same number of divisions. Even if these lines are not worked to exactly they enable one to judge of the whereabouts of the planks and assist in visualising their form or shape.

Method of Planking.—To start actual work, obtain sufficient material, either pine, cedar or Honduras mahogany, and $\frac{1}{8}$ in. thick. This must be as even and straight in grain as possible, any piece with a suggestion of a knot or shake being rejected as unsuitable for planking.

The first plank to fit is the garboard. This plank fits up to the keel-piece and lies in the rebate. It should be about $1\frac{1}{4}$ in. to $1\frac{1}{2}$ in. wide at the mid-section. Its shape can be ascertained by taking a suitable strip of fairly thick paper with one edge perfectly straight and placing this edge in the rebate in the keel at its lowest point. Rub the paper where it overlaps the edge of the rebate and the curvature of the first plank is obtained. Transfer this shape to the timber and cut it accordingly (a fretsaw machine is handy for this work). Try it in place, and with the aid of small planes carefully work at it until it is a perfect fit along the keel. Take care that the plank fits for the whole of its width as well as its length. Fit the other garboard strake in a similar manner.

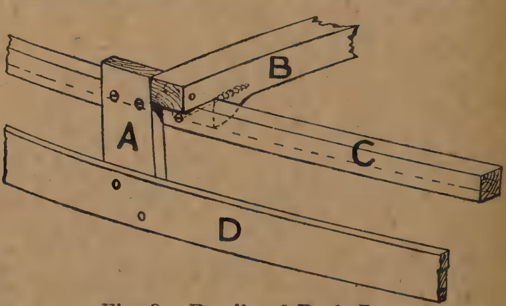


Fig. 8.—Details of Deck Beam

It can be marked off from the first, as corresponding planks are always the same shape as both sides of the hull are alike.

The surfaces of the planks, ribs and rebates, where they join, should be given a coat of good varnish and the planks se-

cured in place to the ribs with fine screws (brass) or, preferably, No. 90 copper pins $\frac{3}{8}$ in. long. Brass screws, $\frac{1}{4}$ in. No. 0, are best used where the plank ends lie in the keel rebate and also where they fit into that on the transom.

Fit the plank next to the garboard either by the use of a paper pattern or by direct marking off, taking every care to make the plank butt up closely against the garboard. The planks should fit closely together, but are not to be forced together, nor should a space be left for filling in with caulking material. For a model a well-fitted butt joint is quite satisfactory. A useful tip when fitting the planks is to hold them in place with Lever's patent clothes pegs. These are small spring-pressed clips, are very cheap, and hold the plank in place if used somewhat as shown in Fig. 7, where A is a rib, B the plank to be fitted, C the clothes peg or cramp, and D a plank nailed to the ribs.

Continue with the planking until the gunwale or topmost plank is reached. This can be shaped but should not be fixed until the deck beams have been fitted. The planking will now have a somewhat ridged effect, which is speedily remedied by vigorous glasspapering until a smooth surface is obtained. The inside of the hull is to have two or three good coats of shellac varnish which may very well be applied before the exterior is glasspapered as it makes a considerable difference to the stiffness of the planks.

The Inwale.—The inwale must next be fitted. This should be a length of oak or ash $\frac{1}{4}$ in. square, and is fitted to the inside of the ribs $\frac{1}{8}$ in. down from the line of the under side of the deck. It is tapered to fit the stem and checked into the stern block or transom. To fit this it will be necessary to cut away the moulds, and this can readily be accomplished with a keyhole saw. The inwale is to be screwed in place with $\frac{3}{8}$-in. No. 0 brass screws through the ribs.

The baseboard may be found somewhat inconvenient and may be removed while the inwales are being fitted; but before doing so make some chocks, or shaped wooden blocks, into which the boat can be placed. The faces of these chocks should be covered with felt where they touch the hull. Mount these on a baseboard, also other blocks to check fore-and-aft movement, thus making a secure stand on which the hull can rest while the interior work is going on.

The Deck Beams.—These should be cut from hard wood $\frac{1}{4}$ in. thick and

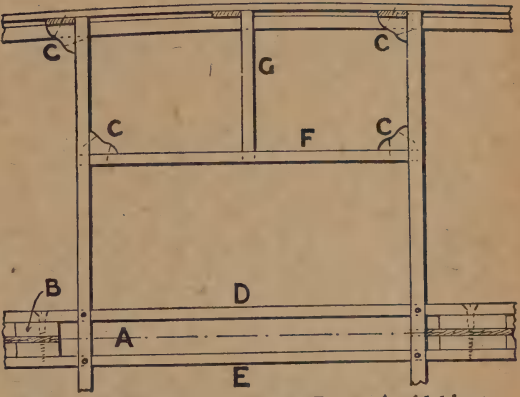


Fig. 9.—Half Plan of Deck Beam Amidships

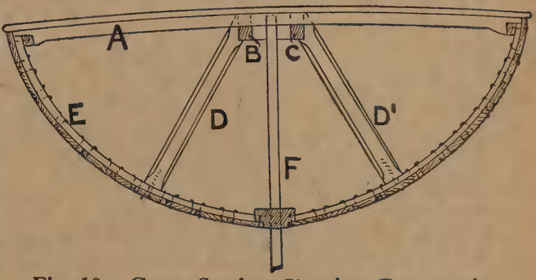


Fig. 10.—Cross Section Showing Construction of Model Racing Yacht

$\frac{1}{2}$ in. wide, cambered to suit, and shaped at each end as shown in Fig. 8, where A is a rib, B a deck-beam, C the inwale, and D the planking. The deck beams are cut to fit alongside the ribs and are therefore able to be fitted before the moulds are removed, thereby obviating any chance of the hull getting out of shape and also making it firmer to work on. They are secured with a $\frac{1}{2}$-in. No. 0 brass screw through the inwales, and further secured with a fine pin through the deck beam and

into the rib. It is wise to drill a fine hole through the deck beam to avoid any risk of its splitting.

The deck beam at section No. 11 is not continuous, as a hatch has to be fitted at

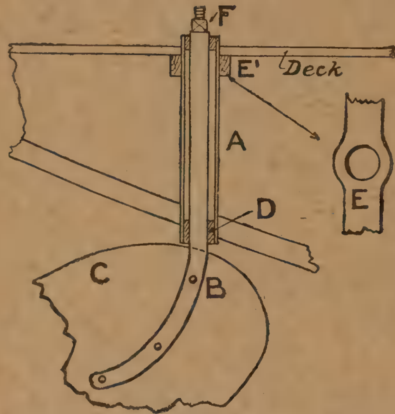


Fig. 11.—Details of Rudder Tube

this station, while that at section No. 16 is to be made from $\frac{5}{8}$-in. thick stuff to accommodate the rudder post. It should be shaped as will be shown later on, and may be omitted entirely at this stage. The deck beams at sections Nos. 7, 8, 12 and 13 are to be checked into and secured to the extensions of the fin.

When the inwales and deck beams are fitted the spaces between the inwale and deck and between the inwale and the gunwale are to be filled in flush with soft pine secured with varnish and pins, the upper surface cleaned off flush and true to the sheer line, while the outer surface is to be cleaned up fair and true so that the gunwale can lie flush up against it, thereby making a strong rim or edge to the hull.

The Gunwale, etc.—The gunwale is now to be fixed in place, and the upper edge cleaned off flush with the deck beams, so that the deck itself can fit down closely on to the whole lot. The stem and stern blocks or fashion piece can be cleaned off at the same time.

Now remove the moulds from the hull. Most of them will come away intact with a little coaxing, but any that may prove to be obstinate should be cut through with a keyhole saw and removed in pieces.

Stiffeners.—Two longitudinal stiffeners D and E (Fig. 9) of mahogany $\frac{1}{4}$ in. thick and $\frac{1}{2}$ in. deep are to be fitted from the stem to the transom. They must be checked into the deck beams and can be screwed to the stern head and to the transom or fashion piece, and should also be screwed to each deck beam with $\frac{1}{2}$-in. No. 0 screws. By using two pieces in this way ample strength is assured, and there is a convenient gap to enable the mast and rudder post to pass through. Fit an intermediate stretcher F of $\frac{1}{4}$ in. by $\frac{1}{4}$ in. hard wood between the beams at sections 10 and 12, and into this fix the short deck beams G for section No. 11, all as shown in Fig. 9. The gaps between the fin and the longitudinals as shown at A should be filled by packing pieces of pine B, and the whole screwed together. This forms a very strong and rigid hull and distributes the strains caused by the fin keel over a wide area. Further strength is given by the knees C, which are glued and pinned in place as shown in Fig. 9. At sections 3, 6, 15 and 17 cross struts between the longitudinals and ribs are to be fitted as indicated in Fig. 10, where A is a deck beam, B and C the longitudinals, D and D′ the struts, E the rib, and F the fin. These struts should be fitted as shown, the lower ends being secured with a $\frac{1}{2}$-in. No. 0 screw right through the planking. They can be cut from $\frac{3}{8}$-in. wide by $\frac{1}{4}$-in. thick hard wood, and should be shaped to an oval section to reduce weight.

Fig. 12.—Mast Step

Rudder and Post.—The rudder and post (Fig. 11) consist of thin brass tubing A $\frac{3}{8}$ in. in diameter, bushed internally at the top and bottom, and drilled $\frac{1}{4}$ in. to accommodate the rudder post B, which may be made of aluminium alloy. Its lower end is curved, as shown, and split

with a hack-saw. Into this slot is fitted the rudder blade C, likewise of aluminium alloy. It is secured with small rivets passed through the curved stem of the rudder post and the rudder blade. A small collar D should be slipped over the post to form a lower bearing.

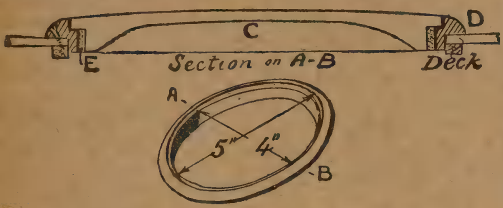


Fig. 13.—Hatch Cover and Coaming

The brass tube A (Fig. 11) may be fitted to the hull by drilling a hole $\frac{3}{8}$ in. in diameter through the keel piece and also through the special deck beam E. Every possible care should be taken to ensure this tube being truly central and perpendicular, as on it the steering qualities of the hull will depend to a very great extent. The tube will be all right if it fits tightly and is secured with a red-lead joint, although a neat metal plate can be fitted to enable it to be screwed to the deck beam if desired. The tube should project $\frac{3}{8}$ in. above the level of the deck beams.

Mast Step.—The only other fitting that must be secured before the deck is fixed is the mast step (Fig. 12). This consists of an aluminium alloy plate $\frac{1}{2}$ in. wide and 3 in. long, shaped as shown. The holes are $\frac{1}{8}$ in. in diameter, spaced $\frac{1}{4}$ in. apart, and are to accommodate a pin on the foot of the mast. This plate is to be screwed to the keel piece with four screws, and must be very secure. Also the row of $\frac{1}{8}$ in. holes must be in line and on the centre line of the boat.

The Deck.—The deck can be cut from one piece of $\frac{1}{8}$-in. yellow pine planed and glasspapered, if a sufficiently good piece can be obtained. If not, it will be best to use two pieces, joined along the centre by a strip of $\frac{1}{8}$ in. thick mahogany arranged so that the joins come over the centre line of the longitudinals, to which they may be fixed with fine pins or No. 000 screws. The deck should slightly overlap the hull sides and be finished as a bead with a half-round section. It may be attached by varnishing all the deck beams, etc., and be secured with fine pins.

The deck should now be lined out to represent planks, and the effect of a covering board obtained by scribing a line $\frac{1}{2}$ in. in from the hull side, and carefully staining it to match the mahogany work. Of course, the lines representing the planks will terminate at the coverboard line.

The whole exterior of the hull may now have a finishing rub up with finest glass-paper, and be painted or varnished as desired; but varnishing is probably the best as it reveals the workmanship of the hull.

The deck can also be varnished at the same time. Be sure to use a good quality varnish. Several coats will be needed. Each one must be allowed to set dead hard before applying the next, and the work should be rubbed down between each coat with pumice powder and water to ensure a fine glossy finish. Keep the boat in a warm dry place free from dust while the varnish is drying off. This will take a long time, but the other deck fittings, spars, sails, and so forth can be made during the varnishing period.

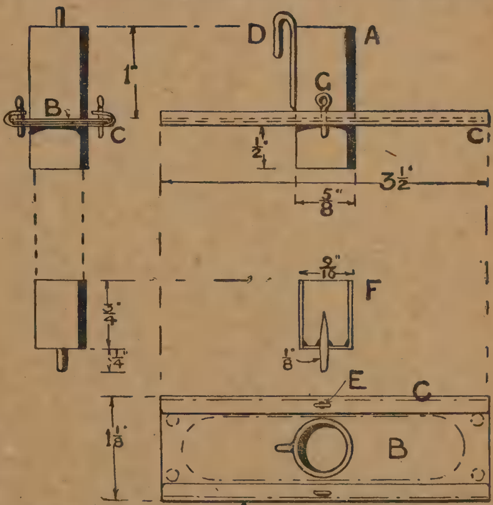


Fig. 14.—Details of the Adjustable Mast Tube

Hatch Cover and Rim.—The hatch cover and rim is perhaps the best thing

to make next. This could be made wholly of wood, but looks clumsy. By far the best plan is to buy or make an oval metal rim and fit a mahogany top to it with a cork or wooden piece inside it. Fig. 13 shows the pieces, and also gives the dimensions; but the exact size and shape are of no great consequence, and may be arranged to suit individual requirements, but should in any case be large enough to admit the hand into the hull to enable it

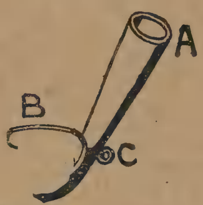


Fig. 15.—Gaff Jaws

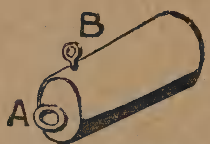


Fig. 16.—Boom Ferrule

Fig. 18.—Stay Plate

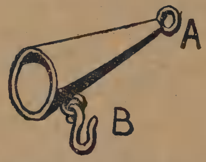
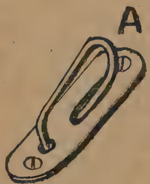


Fig. 17.—Jibboom Ferrule



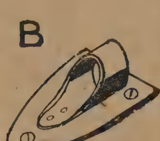


Fig. 19.—Safety Hook-plate

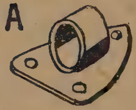


Fig. 20.—Bowsprit Fittings

to be sponged out as occasion requires. Another point that must be borne in mind is that as far as possible there should be no sharp edges or cranks into which any ropes or cords could catch, as if there is a chance for the main sheet to foul anything it will almost certainly do it on the slightest provocation. A cast aluminium alloy rim of the shape shown in Fig. 13 obviates this defect. As can be seen, the mahogany cover C is arranged to fit into a recess cast in to the rim or covering D, and the projecting part of the wooden cover is faced with sheet cork E. The rim is secured to the deck with four small countersunk screws.

Adjustable Mast Tube.—The adjustable mast tube (Fig. 14) can be made throughout from thin brass. It consists of a short length of thin brass tubing A, $\frac{5}{8}$ in. in diameter, brazed to a baseplate B, which is free to slide in the footing C screwed to the longitudinal beams. The hook D of $\frac{3}{32}$-in. brass wire is brazed to the tube A and acts as a gooseneck or support for the main boom. The footing C has a long slot cut in it to allow the mast tube to pass through. A series of holes in B is provided, as is a centering hole E in C, and a brass wire pin G holds the mast tube in place. The lower end of the mast has a ferrule F with a $\frac{1}{8}$-in. diameter centre pin to engage the footstep already fitted to the hull.

Gaff Jaw, etc.—The gaff jaw (Fig. 15) can be built up from sheet brass, and comprises a tapered ferrule A to suit the gaff. The jaws B are cut from $\frac{3}{32}$-in. by $\frac{1}{4}$-in. strip brass, brazed or silver-soldered to the ferrule. The angle of the jaws to the ferrule is to be approximately the same as the gaff makes with the main mast when in normal position. The small screw-eye C is provided to accommodate the sail lashing, and can be soldered in place.

The main boom ferrule (Fig. 16) is somewhat similar to the gaff jaws, but the end is closed by a disc and has a stout screw eye A brazed into it, to fit over the hook D on the mast tube. The small eye B is for the mainsail lashing and may be soldered in place.

The jibboom fitting (Fig. 17) is similar to that on the main boom, but somewhat more tapered. The eye A at the end is to take the sail, while the hook and eye at B is the attachment to the bowsprit.

Plates.—Stay plates are shown by Fig. 18, and can be purchased for a few pence. They are stamped from sheet metal and, having smooth contours, do not foul the running rigging. They can be filed to shape from solid material if so desired; but the stamped pattern is the better, as it is so light and strong.

Hook plates (Fig. 19) are useful and can easily be made from thin strip brass about $\frac{1}{4}$ in. wide by $\frac{1}{32}$ in. thick. To this plate the hook A is brazed. The opposite end is turned down into a hole in the base-

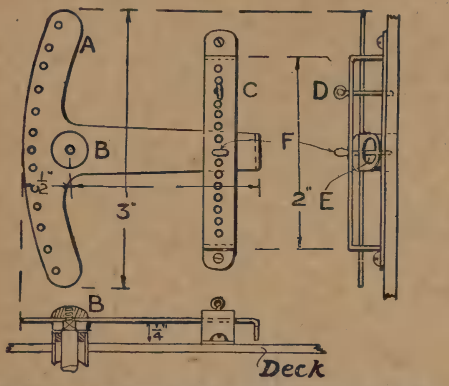


Fig. 21.—Details of Automatic Steering Gear for Model Yacht

plate and thus prevents a hook or eye, which may be attached to it, from being accidentally shaken adrift.

Bowsprit Fittings.—The bowsprit is held in place by the two fittings shown by Fig. 20. The forward fitting A is screwed to the extreme end of the hull, while the shoe or inboard end B is secured to the deck at a few inches inboard, according to the length of the bowsprit. Both consist of a sheet-metal base-plate with a tubular collar or ring silver-soldered into place.

Automatic Rudder.—The automatic rudder is shown in Fig. 21. Its use will be described later, but it should be made up with the other fittings. It consists of a T-shaped quadrant A with a bossing B brazed on. This bossing is to have a square hole cut in it, of a size to suit the rudder post, which should be similarly squared to fit as at F (Fig. 11). This square should not be parallel, but should taper, so that the quadrant can be secured dead tight to the rudder post, for which purpose the cap nut B is provided. This screws on to the top of the rudder post.

Pin Rack.—The pin rack C is made from $\frac{5}{16}$ in. by $\frac{1}{32}$-in. brass strip as shown, and is drilled with holes through which the pins D can be inserted. The centering hole F should be drilled in such a position that a pin passes through this and through the quadrant leg when the rudder blade is truly in the axial plane of the ship, or "centred." The extreme end of the quadrant leg E is turned down at right angles and drilled with a large hole, about $\frac{5}{16}$ in. in diameter. The small holes in the quadrant are for the main sheet hooks and may be full $\frac{1}{16}$ in. in diameter.

Masts and Spars.—The masts and spars can be made from sound pine, straight-grained and free from knots or splits. The dimensions can be obtained from Fig. 26 by adding an appropriate amount to the dimensions given for the sails. Thus the main mast becomes 42 in. long from deck to truck, the main boom $40\frac{1}{2}$ in., the jibboom 24 in. and the gaff $23\frac{3}{4}$ in. The mast is $\frac{5}{8}$ in. in diameter where it fits into the mast tube, and should taper gradually to within a couple of inches of the truck, at which point it should taper abruptly to $\frac{3}{8}$ in. in diameter and terminate in a circular truck or cap. The mainboom should be $\frac{9}{16}$ in. in diameter in the centre and taper both ways, and the jibboom $\frac{7}{16}$ in. in diameter, tapering both ways. The gaff is of similar dimensions, but is largest at a point 6 in. from the gaff jaws.

Sails.—The sails are best cut out from union silk. The material should be pinned with drawing-pins to a table or board, and marked out in pencil to the exact shape

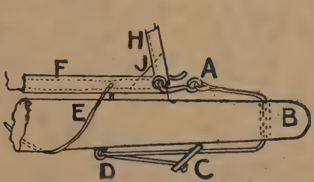


Fig. 22.—Detail of Outhaul

of the sails. An extra amount must be allowed if the edges are to be hemmed; but if the edges are to be bound with the usual prussian binding they can be cut to their shape with a very sharp penknife or razor. The utmost care must be taken when sewing on the binding to keep the

sails perfectly flat. The essential feature of a good sail is that it should be flat, and it should be quite free from wrinkles or creases. Perhaps the best way is to tack on the bindings after having creased it down the centre, and then to machine the two edges, somewhat as indicated at F in Fig. 22. If it is decided to hem the edges it can be done in an ordinary sewing machine if it has a "hemmer." A corner piece—triangular in shape—should be stitched to the sails at all the corners to give added strength for the eyelets as shown at J in Fig. 22.

The spinnaker is shown dotted in Fig. 26, and can be made up to the sizes shown, also the spinnaker boom and fittings.

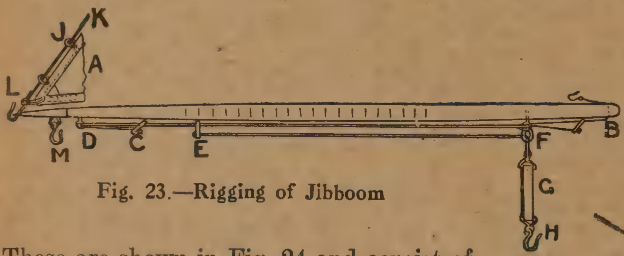


Fig. 23.—Rigging of Jibboom

These are shown in Fig. 24 and consist of a brass tube ferrule B, with a long hook and screw-eye C. This hooks into a shroud plate (Fig. 18, p. 272).

Lead Keel.—At this stage it is well to determine the exact weight of the lead keel. This is accomplished by placing the hull in water with all its sails and fittings complete, and then putting weights into the hull until she floats at the exact waterline, which should measure 40 in. Weigh these weights, and this will be the keel weight, about 9 lb. Cast a lead keel, screw it to the fin, then test the boat, and adjust by scraping off some of the lead or adding a little in the interior.

Fitting up and Finishing.—Nothing now remains but to step the mast, securing it by two shrouds, one each side. Then fit up the bowsprit and the jibboom.

The jibboom is shown in detail in Fig. 23, and is clothed with the jibboom ferrule M (Fig. 17). The jib stay K hooks into the eye at the end L of this ferrule, and is attached to a screw-eye in the mast by means of a hook and bowsie. The jib is secured to this stay by sewing on a number of small rings J, spacing them about $1\frac{1}{2}$ in. apart. The eyelet in the foot of the jib is lashed to the hook on the jib stay as at L (Fig. 23). A line is then taken from a screw-eye D immediately aft of the ferrule to another screw-eye F, and made taut with the bowsie C. On this line runs another bowsie E, which has a cord taken through a ring hooked into the eye F, and terminates in a flat rubber band G with a hook H at the end of it. It is convenient to mark the boom with $\frac{1}{2}$-in. divisions as shown, so that once the best sailing position has been found it can be noted.

At the inboard end of the boom is a "traveller" B, shown in greater detail

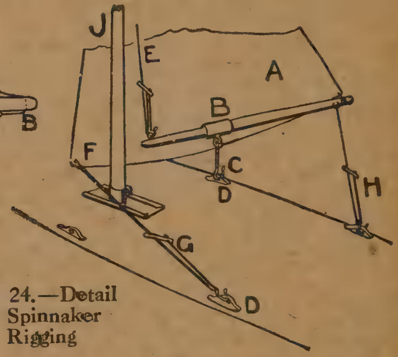


Fig. 24.—Detail of Spinnaker Rigging

in Fig. 22. This shows the end of a boom, and that it is drilled through at right angles near the end as at B. A cord reaves through this hole and terminates in a hook A which hooks into the eyelet in the foot of the sail, as at J. The other end of the cord has a bowsie C, and is taken through a small screw-eye D. This outhaul is used to draw the foot of the sail up taut.

The sails are further secured to the spars by the light cord E, which is sewn through the sail and turned round the boom as shown. This arrangement is used on the mainboom and on the jibboom.

The spinnaker hooks direct to a screw-eye on the mast; a backhaul with bowsie adjustment is shown at H (Fig. 24). The sail is set by means of the uphaul E. A spinnaker sheet is attached to the sail as at F, while a bowsie G provides adjustment and hooks into a shroud-plate D.

The sails can now be set, and it only remains to fit up the automatic steering gear, and the various ropes that are used in conjunction with it (see Fig. 25).

The mast is shown at A, the main boom ferrule at D, the outhaul at B, and the "beating sheet" at F. This hooks on to a wire "hawse" which consists merely of a piece of $\frac{3}{32}$-in. diameter wire bent to shape, the ends being turned over at right angles

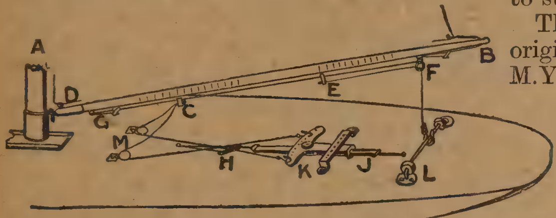


Fig. 25.—Automatic Rudder

and riveted and sweated to circular deck plates as shown at L. A rubber disc to act as a buffer is an advantage, as it tends to avoid spilling the wind from the sail when going about. The beating sheet has an adjusting bowsie E running on the line G, which is kept taut with a bowsie.

Fitting up Automatic Tiller.—To fit up the automatic tiller it is only necessary to see that the quadrant K is securely attached to the rudderpost and that the pin rack is well fixed to the deck. Now fix a small screw-eye into the deck on the centre line and about $2\frac{1}{2}$ in. behind the end of the quadrant, also another screw eye about 6 in. ahead of it. Then insert a rubber band through the hole in the arm of the quadrant, and make one end of it fast to a line leading to the after screw-eye. A similar connection is to be made to the forward screw-eye, but in this case an adjustment must be provided by the bowsie as shown at H (Fig. 25) to enable the tension of the elastic to be varied.

Now fix two small sheaved pulley blocks just ahead of the forward screw-eye as at M, and through these lead the "running sheets" which terminate in one bowsie C. The running lines cross over as shown and hook into the holes in the quadrant. By this arrangement whenever the boom goes over to starboard the helm is put over to starboard and vice versa.

The action and use of this device, which originated with Mr. Braine, of the M.Y.S.A., is both simple and effective. Its chief use is in running before the wind, for as the wind pressure on the sail tends to drive the boat off her course, the rudder is automatically put over, and thus keeps the boat on a true course.

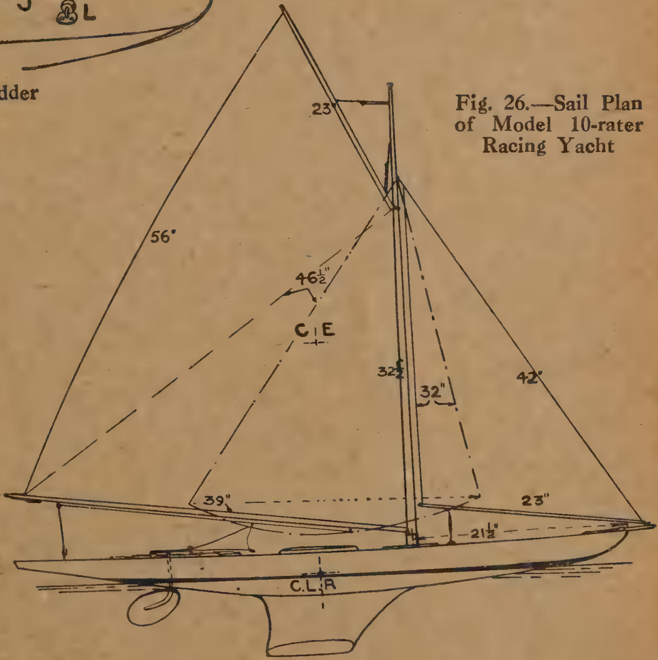


Fig. 26.—Sail Plan of Model 10-rater Racing Yacht

Considerable variation is possible, as by varying the tension on the rubber or by changing the position of the running sheet on the quadrant varies the amount of swing in the rudder, and also the wind pressure required to actuate it.

Household Electric-Light Repairs

EVERY householder whose premises are supplied with electric current will find occasional need for work to be done in the way of maintenance, repairs, or extensions. Many of these jobs are of quite a trivial nature and hardly seem to justify calling in the services of a professional electrician or wireman, and with reasonable care can quite well be carried out by the occupier himself if he knows how to go about them.

Those who have experimented in a haphazard way, resulting perhaps in "shorts," burnt fingers, and "shocks," may have acquired a certain degree of caution, not to say disinclination to meddle with matters they do not fully understand, and a few brief and simple instructions may therefore help them to regain lost confidence.

The non-electrical man is as a rule entirely ignorant of the scheme which supplies him with electric current for light and power. Beyond the fact that there exists somewhere on the premises an appliance in the shape of a "meter," visited quarterly by an official for the purpose of recording the "units" consumed, the method of supplying and distributing current is usually a matter the consumer does not worry himself about. He knows probably that there are two kinds of electric current, "direct" and "alternating," and also that they are not always supplied at the same voltage or pressure. But so far as the actual generation of current at the electric power station is concerned and its distribution to the consumers' premises through the main cables he has no occasion to concern himself. It is only at that point where the "service cable" brings the current into the premises from the outside mains, where his real interest commences; for should any faults occur on the mains or service cables, and extensions or adjustments be necessary, the supply authorities look after all that is essential in this regard without troubling the consumer. But where the service cables end, usually at the meter, the internal wiring and fittings become the occupier's property and the liability for their upkeep and repair is his.

To the amateur the distribution of the electric supply is vague in the extreme, principally because the cables and wiring are for the most part concealed under flooring or in the walls, and their course is difficult to follow from casual inspection. All he sees is a switch upon the surface, a bracket or a ceiling pendant lamp, a fan motor or what not, which responds to the operation of the switch. The means by which the control is effected, the prevention of accidental damage, etc., is not obvious to the eye as a rule.

Typical Electric-Lighting Circuit in a House.—Let an investigation be made, therefore, of a typical electrical circuit from the point where the service

cables enter the premises to the lamps themselves or other appliances connected on. In Fig. 1 it is seen how the street mains are tapped and service cables taken into the house. At the first point of entry are fitted the service fuses which are the property of the supply company, and sealed so that neither the consumer nor any unauthorised person can tamper with them. Upon the same board carrying the service fuses is sometimes placed the meter, but this is occasionally mounted separately. The meter is also the company's property, the company being responsible for its condition, as well as for the service fuses ; but all the wiring and fittings subsequent to the meter have to be provided by the consumer and kept by him in proper repair and working order.

Service Fuses.—The reason for sealing the service fuses is to limit the maximum current that can be taken from the main service, and if the consumer does not proportion his own fuses so that they interrupt the supply before the service fuses fail he stands a good chance of blowing the service fuses instead if anything unforeseen occurs, which necessitates application being made to the officials for their renewal, and is frequently made the occasion of a fine as well.

The service fuses, therefore, are the vital point in the whole system, and the whole supply to the premises will be interrupted if they fail. They act as a check against carelessness or accident on the part of the residents, and are a safeguard against faults recurring on the wiring of which the consumer is ignorant, and which might otherwise lead to fires.

When a new installation is finished the supply company, after inspecting and passing the wiring, will proportion the size of their service fuses to the number of lamps or other apparatus connected on, with a sufficient margin or reserve to enable temporary or occasional small overloads to be carried without discontinuing the supply, so that when contemplating extensions or alterations one of the first things to be considered is the effect it will have upon the total current consumption, and whether the service fuses are capable of carrying the new load. If there is any doubt about it, always consult the supply authorities, as they are naturally always ready to increase the size of their supply cables, fuses, or meter, in order to sell an additional number of units, except when some temporary cause may impose restricted service.

Referring back to Fig. 1 it is seen that the current after being metered is taken first to a double-pole switch and fuse ;

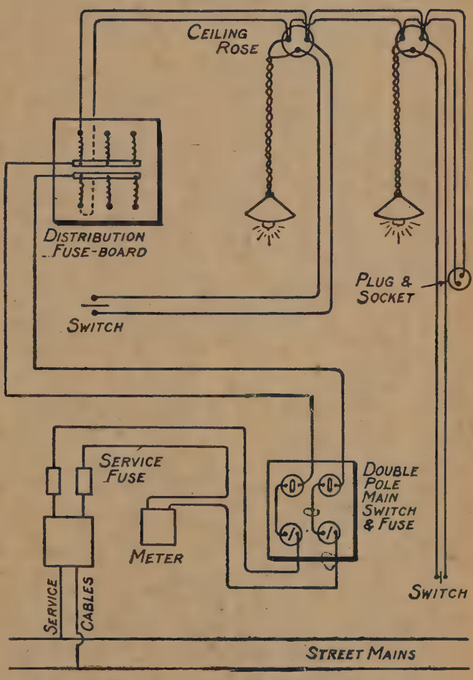


Fig. 1.—Diagram illustrating how Electric Current is distributed from Street Mains to House

this switch enables the consumer to disconnect the supply from the whole of the house at will. Note, also, that the cables first serve the switches and then the fuses, so that in the event of any fuse requiring renewal the main switch is first opened (shut off), and there is no risk of getting shocks from "live" wires, as these are very disconcerting to the inexperienced amateur wireman.

Electric Shock.—There is no great danger to be anticipated from occasional shocks received on an ordinary lighting system to persons in a normal state of health. The shock is caused by the nervous stimulus of the current setting up muscular contractions, and as nervous susceptibility is greater in some individuals than in others, all are not equally affected. The actual cause of the shock is the current flowing through the tissues of the body, and the strength of the shock is determined by the actual amount of the current. This, again, is regulated by two things, the voltage or pressure of the current, and the resistance offered by the victim; thus a low voltage is less likely to create

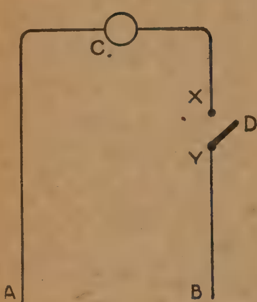


Fig. 2.—Part of Circuit containing a single-pole Switch; not entirely isolated

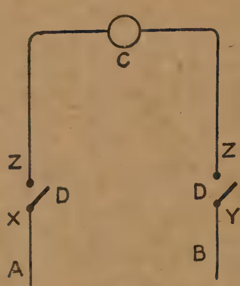


Fig. 3.—Part of Circuit containing a Double-pole Switch; wholly isolated

shock than a high voltage, and again, a small area of contact such as a touch with the finger tip is less likely to be productive of serious shock than if a wire at the same potential were grasped with the whole hand. The presence of moisture greatly assists the passage of a current, and there is far more likelihood of receiving a shock in a damp situation than in a dry one. In a bath, for instance, a comparatively low voltage such as 25 volts might easily pass sufficient current to be dangerous if not fatal, on account of the very low resistance. To a person with a dry skin, however, and standing on dry ground, and without nails in the shoes, an accidental contact with a live circuit of 250 volts might cause very little inconvenience. As a general rule, however, anything between 100 and 250 volts should be very carefully handled, and if any doubt is felt whether a circuit is live or not always test it with a lamp, one terminal of which is wired to the cable or fitting, and the other end to a water main. If the lamp reddens ever so little the circuit is live, and the main switch should be sought for and turned off. The fact of the lamp not glowing with full brilliancy does not indicate that there is less danger of shock, because it takes far less current than would light a lamp or even redden the filament to cause a shock.

Need of Double-pole Main Switch.—It is always essential to provide double-pole switches for the main switch as otherwise the supply can only be interrupted, but not *isolated*. In Fig. 2, the supply wires are shown at A B, a lamp at C, and a single-pole switch at D. If D is opened it disconnects the supply of current from B to C, but it does not isolate any of the cables or fittings, since current can pass right round the circuit from A to X or B to Y, leaving it possible to get a shock from any part of it. The effect of substituting a double-pole switch, however, is shown in Fig. 3. Here two switches D D are fitted, one on each of the supply wires A and B, arranged to operate together and disconnect lamp C from the supply. On opening switch D D, the part of the circuit Z C Z is now entirely disconnected from A B and that part of the circuit now becomes "dead," the live portion being limited to A X and B Y. This is the reason that the double-pole switch is placed immediately after the meter position, in order that the whole supply to the house may be not only discontinued, but entirely isolated. No repairs, tests, or fuse replacements should be attempted until this main double-pole switch has been opened, and then there will be no risk whatever of getting shocks.

Distribution Board.—After the main double-pole switch the next point of importance is the distribution board. At this point the main current is split up into branch circuits, each carrying a limited amount, and each protected by

its own fuse. Certain groups of lights are controlled by each section, and if one fuse happens to go it does not put out all the lights in the house. In the diagram given in Fig. 1, one branch circuit is shown with double-pole fuses, and various fittings. The fuses, if both are withdrawn, allow for one section of the circuit to be entirely disconnected and isolated for testing purposes, should it be needed at any time, without discontinuing the supply to the other parts of the house. The rest of the circuit shows how the wiring is carried to various ceiling roses, pendants, brackets, switches, or wall sockets, and serves to give a general idea of the system, although of course no two dwellings are in the ordinary way wired alike, as the cable runs would follow the shortest and most convenient routes in each instance.

Leakage.—As a general thing the amateur wireman is only concerned with three troubles. (1) Leaks, faults, and shocks. (2) Repairs to fittings, and (3) Extensions. Most lighting and house circuits have both sides of the supply insulated. Occasionally one side is earthed, especially if it happens to be a 3-phase system or a 3-wire supply with the middle wire and one outer used for lighting and both outers used for power. Information as to the system of supply and whether intentionally earthed or not is always readily obtained from the supply company. On a system with both sides insulated, the presence of shocks indicates that a leakage is occurring on one side. But if the system is already earthed intentionally on one side it will always be possible to get a shock when in contact with the opposite side. Figs. 4 and 5 make this clearer. In Fig. 4 both sides are insulated, and no shock could be taken either at A or B because, although the hand is earthed through the body and feet to the ground, both wires are insulated from the ground. In Fig. 5, however, only one wire is insulated, and the other one is earthed. Anyone touching the earthed wire at B would receive no shock, because both are at the same potential, but if a bare portion of the insulated wire were touched at A while the person was still earthed he would receive a shock at full potential. It is easy to see, therefore, that in order to obtain complete immunity from shocks the only

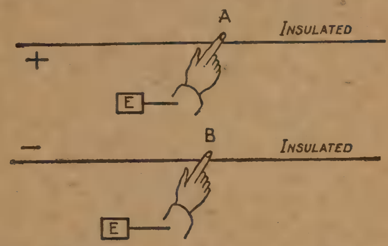


Fig. 4.—Diagram indicating that Touching an Insulated System does not cause Shock

safe method that guards against all conditions is to stand on an insulating mat, or to wear rubber gloves when experimenting.

All house circuits should be wired so that the supply first enters the main switch, so that all subsequent parts of the circuit are made "dead" by opening this switch. This allows the fuses to be renewed without risk of shock.

Fuses.—Fuses are of two types, the "bow" type in which the fuse wire is simply fastened by passing it round the head of a screw in one of the brass contact blocks, and the "bridge" type in which the fuse wire is screwed to terminal blocks on a porcelain bridge or some other insulating material and pushed home

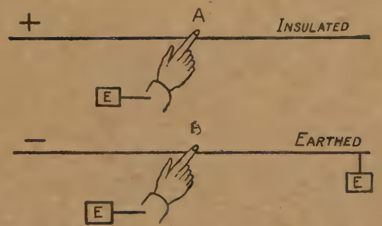


Fig. 5.—Diagram indicating that Touching an Earthed System on the Insulated Side causes Shock

between two spring clips or sockets. This type is preferable because the bridge can be handled whether the circuit is live or not, being of insulating material, and a fuse can be withdrawn, examined, and

replaced in a very few moments without the need for opening the main switch. Fuse wires are very seldom attached by soldering, as fuse replacements are always urgently in demand, and there is no time available for looking up soldering materials and making the iron hot, etc.

The universal practice is to give the fuse wire a turn or two about the binding screw, and then tighten it down, but there is a right and a wrong way of doing even a simple matter like this. Figs. 6 and 7 show the difference. In Fig. 6 the wire is turned round the shank of the screw

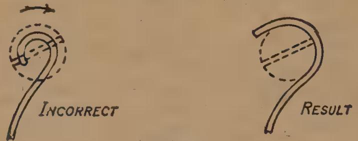


Fig. 6

Fig. 7

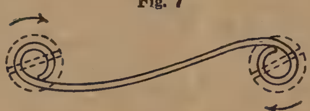


Fig. 8

Figs. 6 to 8.—Methods, Wrong and Right, of Attaching Fuse Wires to Screws

in a left-hand direction; consequently, as the screw head revolves in tightening up the loop opens out and probably the head of the screw passes through it, making imperfect contact. The correct way is shown in Fig. 7; the wire loop then tends to close up on tightening down instead of spreading out. There is always some risk, in the case of very fine fuse wires, of the wire getting caught in the threads of the terminal screw, and if it catches it will probably be dragged and stretched out until considerably thinner than its proper section; when this happens the fuse will go with less current than the normal. To obviate this happening a thin brass washer should always be put immediately under the screwhead, as this prevents the threads from catching and rotating the fuse wire. As an additional precaution, always leave a little slack between the two ends and do not wind the loop too tight. Fig. 8 shows a correctly set fuse wire.

In renewing fuses it is best to use a hard metal such as copper rather than any of the soft tin alloys. In clamping down the screwhead the fuse wire is then not so apt to get cut through. It is not advisable to have a number of different gauges about as it leads to mistakes being made, and the wrong carrying capacity being used. Every fuse in succession from the service fuse onwards should be of a lower carrying capacity than the preceding one. If the service fuses are proportioned for, say, 10 amperes, the consumer's main fuses should be wired for 9 amperes, and the branch fuses, of course, would be smaller still. It is therefore well to use one gauge only, say No. 41 S.W.G. bare copper which will fuse at 3 amperes. One strand of this is suitable for each of the distribution-board circuits, and two or more strands can be twisted together when heavier currents are being dealt with.

Lamp Renewals.—Fuse renewals form the most frequent repair called for. Damaged and burnt-out lamps are also of frequent occurrence, but their renewal calls for little comment, except the rather obvious recommendation to see that the lamp voltage is correct for the circuit. The marking on the brass cap or the bulb of the old lamp is the best guide, and the voltage and candle power should be repeated. It does no harm to replace a lamp with another of a lower watt consumption, but if a lamp having a larger consumption is substituted naturally a heavier current is taken and the fuses may give trouble.

Switch Troubles.—Switches, lampholders, wall plugs, etc., seldom give trouble unless badly used, but there is a certain amount of wear and tear on a tumbler switch which may lead in time to adjustments being necessary. The first indication of this is when the light

flickers on moving the switch knob about slightly, and there may also be heard at the same time a slight hissing sound from the interior indicating the presence of an arc which if allowed to continue many minutes will burn away the contacts. If the damage has not gone too far adjustments can usually be made by removing the switch cover and closing in the forked contact pieces into which the bridge descends when the knob is pressed. Such repairs as these should not be carried out when the current is on. A switch not quite tightly screwed to the wall is liable to give trouble.

Lampholder Troubles.—Trouble in lampholders may arise from the spring plungers which make contact with the lamp terminals sticking, and by the porcelain interior upon which they are mounted getting skewed round and coming out of its proper relation to the slots in the sides of the holder with which the pins in the lamp cap engage. There is usually a groove in the side of the porcelain and a corresponding key formed in the body of the holder, and these two need to be kept in their proper positions when screwing home the locking ring, otherwise the slots will fail in holding the cup in the right position to make contact with the brass plates on the lamp cap, and may even short-circuit and blow a fuse.

The same may happen if one or two stray strands of the copper flexible with which the holder is wired come too far through the terminal holes, or get doubled back under the porcelain and make contact against the brasswork. Even if this does not "short" it will set up leakage and cause shocks. In the event of cracked porcelains or damaged parts, do not attempt any repair at all but replace them entirely with a new holder which will cost less and ensure satisfaction.

Alterations to Lamp Positions.—It is frequently required to alter the position in which a lamp is hung, and it is here that the great advantage of electric lighting becomes evident on account of its flexibility.

Any existing lamp-socket whether pendant or bracket can be used, and a sufficient length of twin flexible cord to reach the new position and an adapter are all that is needed. An adapter is simply a fitting that is a replica of an ordinary lamp end and fits into the socket in the same way. The cord is attached by clamping to two terminal posts in the interior, the top half of the adapter being made to unscrew for the purpose. A new suspension point from the ceiling is then settled on, the plaster carefully probed with a long fine bradawl to find a suitable fixing, and a porcelain-bushed screw-eye inserted in the desired position.

Flexibles can also be carried round skirting and along door jambs in the same way for temporary work, but such practice is hardly to be recommended as the wiring is too easily susceptible to damage without casing or other protection. Insulated screw-eyes, however, are extremely handy for a number of extension purposes, especially for ceiling work. It is less conspicuous to pass round a cornice or along a picture rail in preference to crossing a white ceiling, and the cord should be strained just tightly enough to take up all slack and a knot made in it close against the last screw-eye. This is less unsightly and looks more workmanlike than letting the wire dangle in festoons.

Do not forget that every additional light means extra current, and is an extra load upon the fuses. Also do not allow any particular circuit to be loaded up to more than 3 amperes if on 220 volts, or 5 amperes on 110 volts. To ascertain the current, if no ammeter is available, add the total watts marked on the lamp bulbs and divide by the circuit voltage.

Workshops, Poultry-houses, etc., etc.

A SPAN-ROOF WORKSHOP OR GARDEN HOUSE

The span-roof structure illustrated by Fig. 1 below and by Figs. 2 to 5 on the next page is of a useful size, suitable for a variety of purposes, and made in such a way that it can be divided into sections for removal if necessary. It has been made as different in appearance from the commonplace as possible within the limits of simple carpentry; and if a bench is desired along the side opposite the door, a window can easily be arranged on that side. For the roof it is suggested that feather-edged weather-boarding be employed instead of the rather mean-

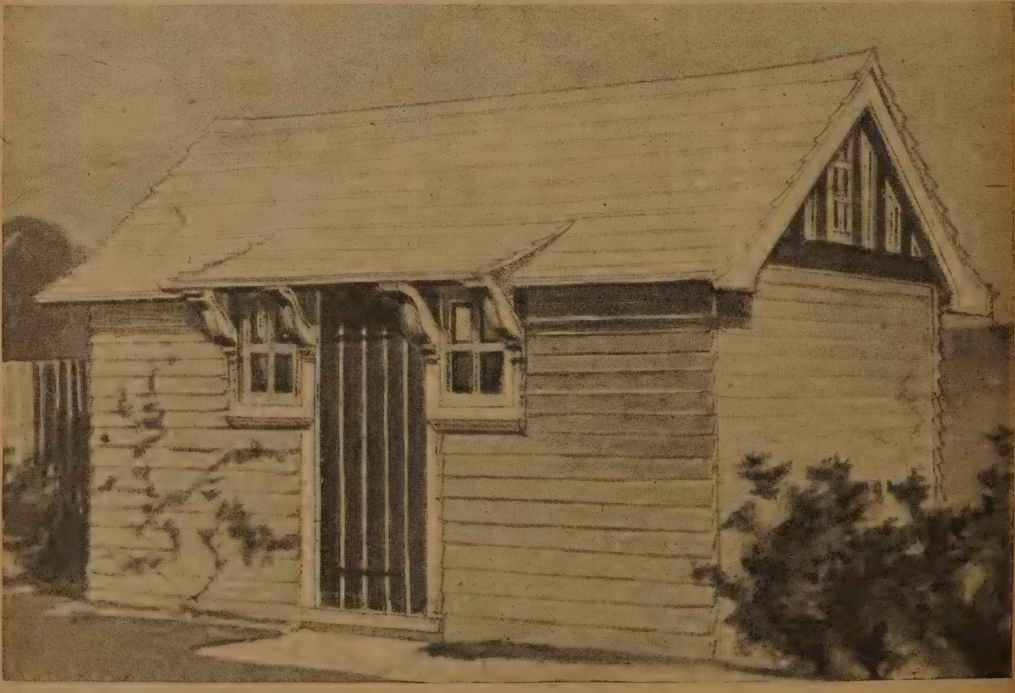


Fig. 1.—Span-roof Workshop or Garden House

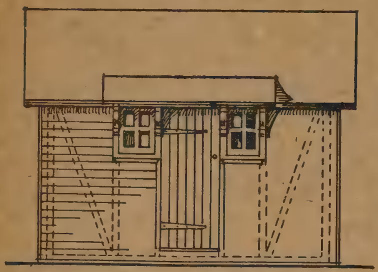


Fig. 2

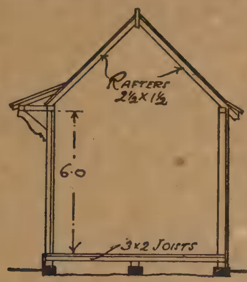


Fig. 3

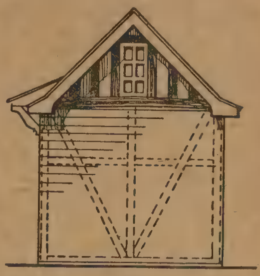


Fig. 4

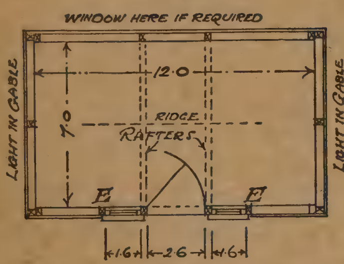


Fig. 5

Figs. 2 to 5.—Front Elevation, Cross Section, End Elevation, and Horizontal Section of Span-roof Workshop

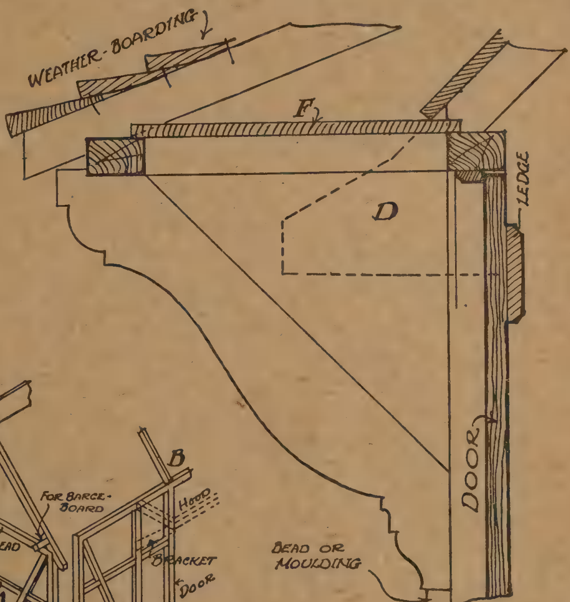


Fig. 10.—Detail of Bracket to Hood, etc.

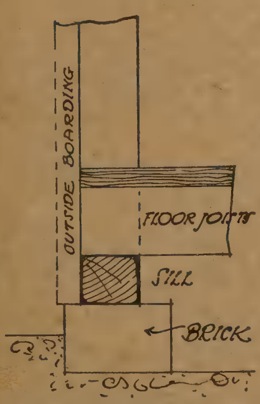


Fig. 8.—Section Through Sill, etc.

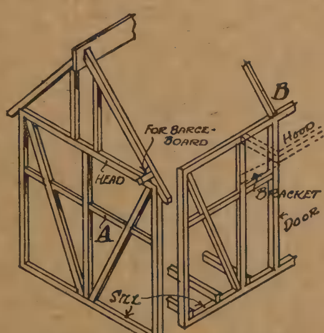


Fig. 6.—View of Workshop Framing

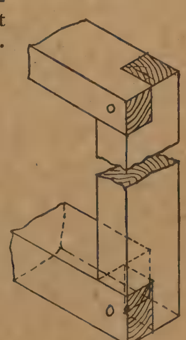


Fig. 7.—Sill and Head Jointed to Post

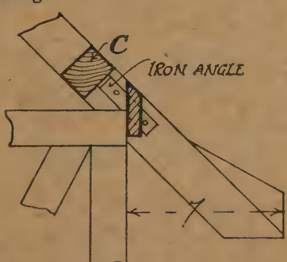


Fig. 9.—Foot of End Rafter

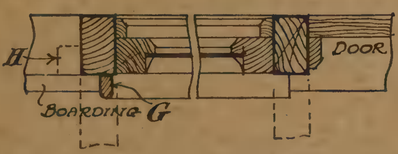


Fig. 11.—Section Through Window, Door Post, etc.

looking tarred felt so much used. The same kind of boarding can be used for the sides, unless it is preferred to matchboard these, in which case the joints would be vertical. The surface can be painted or given a couple of coats of some preservative, and the door and windows should be painted a distinctive colour.

The framework is explained by the isometric view (Fig. 6), each side being put together as a separate section and connected to the others afterwards with two or three $\frac{1}{4}$-in. bolts at each angle. For the end section the sill ($2\frac{1}{2}$ in. by 2 in.) and head ($2\frac{1}{2}$ in. by $1\frac{1}{2}$ in.) are halved to $2\frac{1}{2}$-in. by $1\frac{1}{2}$-in. end posts as in Fig. 7. A central upright is tenoned between them, and diagonal braces are fitted as shown without any joint, and afterwards a number of horizontal pieces are butted tightly in between, as A (Fig. 6), at a height corresponding with that of the window sill (that is, about 4 ft. up). The sides are made in a similar manner, so that when all four sections are bolted together, 3-in. by 2-in. floor joists can be nailed on top of the sills as in Figs. 6 and 8, bearing in the middle on a central sill or plate, as in Fig. 3, the top being finished with $\frac{3}{4}$-in. floor-boards.

The roof should be of a good pitch, and might have a 6-in. by 1-in. ridge projecting about 7 in. at the ends, where it is supported by rafters butting against it, and notched over the end framing as in Fig. 9, which also shows how the rafters are intended to overhang. A wedge-shaped piece 6 in. long is added to tilt the roof up a little, greatly improving the effect. Two upright supports are fixed in each gable 1 ft. 3 in. apart, to take the small fixed window there, and support the roof. The intermediate rafters are similar to the end ones; but the two ends over the door B (Fig. 6) do not project. Barge-boards about $4\frac{1}{2}$ in. wide, as in Fig. 4, form a desirable finish to the gables, and are fixed to the ends of the ridge and to square pieces C (Fig. 9) of the same projection, fixed to the rafters with small angle-irons, adjuncts that often prove of great use in this class of work. The shaped feet of the barge-boards are made by the addition of wedges to the rafters, and similar pieces on the under edges, cut to the curve shown, which looks better than the perfectly plain outline otherwise obtained. Fig. 9 shows a small piece of boarding fixed between the rafters to stop the gap that would otherwise be left open. The roof is boarded completely in before the projecting hood over the door is put on, a small splayed piece being fixed along each side of the ridge in order to start the slope with a close joint. The eaves should overhang a little beyond the rafters except where the hood is to come, at which point the overhang at each side must be stopped on a projecting piece as D (Fig. 10) screwed against the posts E in Fig. 5.

As an alternative to this form of roofing, a splayed piece might be fixed along the side of the ridge, and another along the head of the side to take boarding, with its joints running up and down from eaves to ridge. This would lend itself to the boarding being put together in sections for transit.

The hood is dotted in Fig. 6 and shown in detail by Fig. 10. It consists of a horizontal framework halved together, fixed at the same level as the head of the side framing over the door, and supported on four shaped brackets 2 ft. 1 in. long, cut out of 4-in. by $1\frac{1}{2}$-in. stuff, the soffit being filled in with thin matchboarding F, and the whole roofed with short rafters at a flatter pitch than the main slope, and curved a little if possible, covered with weather-boarding. A small stop is planted round the door opening to take a door of matchboarding on stout ledges and braced if necessary, hung with cross-garnet hinges to open in or out as preferred, and fitted with any type of latch.

Fig. 11 is a plan of a window and part of the door, the position of the brackets being partly shown by dotted lines. Note the small stops fixed round the inside to form a rebate for the sash, which is of the ordinary type, divided into small panes, hung either at the top or one side to open outwards, and fitted with an iron casement stay. A bead or moulding G is fixed

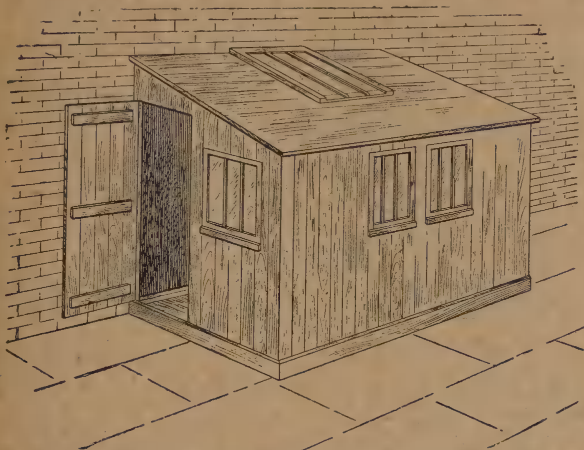


Fig. 12.—Portable Lean-to Workshop

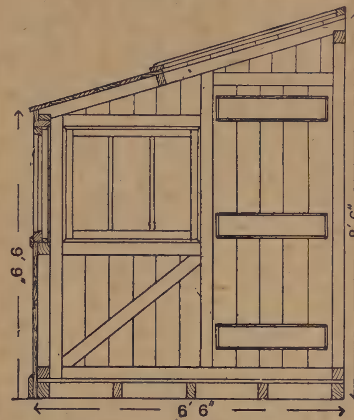


Fig. 15. — Cross Section on A A (Fig. 14) Showing Left-hand End

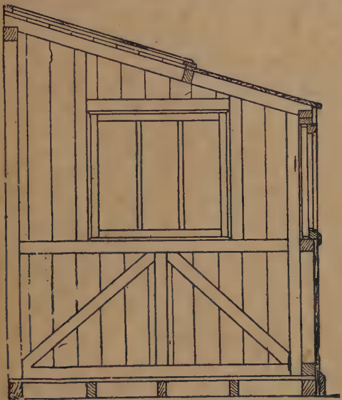


Fig. 13.—Cross Section on B B (Fig. 14) Showing Right-hand End

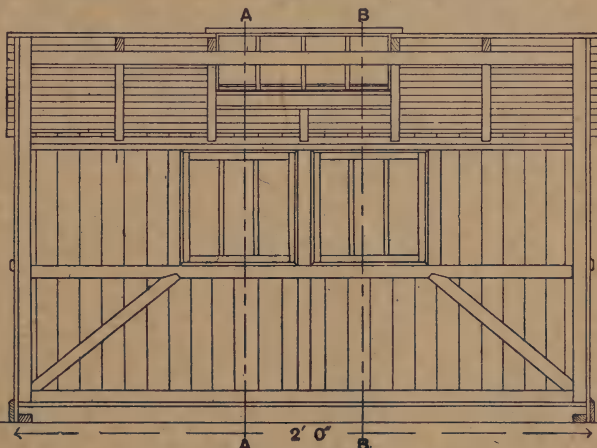


Fig. 14.—Inside Elevation of Slide

Fig. 18

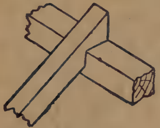


Fig. 19

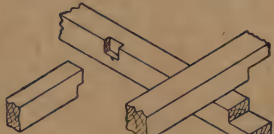


Fig. 17

Figs. 17 to 19.—Joints in Workshop Framing

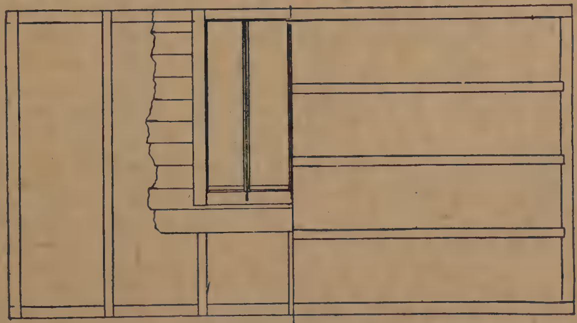


Fig. 16.—Two Half-plans of Workshop

to finish the ends of the boarding, and serves as a projecting sill under the window, being quite sufficient for so completely sheltered a position. At the side it stops under the bracket, and the bottom of this is kept out enough for the purpose (see Fig. 10). Where the end brackets come against the posts a small piece as at H in Fig. 11 will need to be fixed at the side to take the ends of the boarding.

The gable ends can be treated as half-timber work with pleasing effect, by boarding them up with as smooth faces as possible, and planting $3\frac{1}{2}$-in. uprights and 6-in. horizontal pieces on them, the last being slightly cambered along their upper edges. These in dark green or brown look well on a white ground, while the small window in the centre at each end prevents a monotonous appearance.

As dry a position as possible should be selected for the workshop, and its floor should be well above the surface of the ground. A bed of concrete or well-rolled gravel would make an excellent base; but a layer of ashes will also serve fairly well, especially if the framework can be raised on one course or more of bricks laid lengthwise on their flat sides as in Fig. 8. Whatever the base, it should be carefully levelled all round and rammed solid. For the woodwork coming near it, tar will be found an excellent preservative against wet-rot.

A LEAN-TO WORKSHOP

The plainer structure shown by Figs. 12 to 16 has a boarded floor, and is so arranged as to be a tenant's fixture, and to be easily taken down or erected if necessary. It can be formed of six separable pieces, namely, the roof, two sides, two ends, and floor. In some cases, of course, the wall might serve the purpose of one side, and then there would only be five pieces. As the illustrations show the construction very fully, only the leading particulars will be given.

The four outside pieces should be formed of 3-in. by 3-in. timber, half lapped together at the angles. The joists may be 3 in. by 2 in., notched in as shown in Fig. 17. All the joints should be firmly fixed together with $2\frac{1}{2}$-in. nails. Prepared floorboards will be preferable for the floor, and it will be found to compensate for the little additional expense to have them grooved and tongued. The boards should be fixed to the joists and sills with 2-in. or $2\frac{1}{2}$-in. floor-brads. The edges of the boards should finish flush with the outside.

The framing of the sides and ends should be of 3-in. by 2-in. stuff, except the top horizontal piece, which may be 3 in. by $1\frac{1}{2}$ in. The pieces should be cut off a little more than the finished lengths, planed up, and set out for mortising, tenoning, etc. The several pieces may then be cut to their respective forms, fitted together, wedged, and nailed. The outsides should be covered with $\frac{3}{4}$-in. or $\frac{7}{8}$-in. prepared matchboarding. The method of arranging the timbers is shown in Fig. 15, and enlarged details of the principal joints (except the simple horizontal mortise and tenon) are given by Figs. 18 and 19.

For the rafters, 3-in. by 2-in. stuff will be suitable, and they should be cut top and bottom to form shown in Figs. 19 and 20. (If a skylight is required, it will be necessary to prepare for it in the manner shown.) Three-quarter-inch boarding should be fixed to the rafters. Matchboarding, with the best side inside, would, of course, have the best appearance, though it would be a trifle more expensive than plain boards. The roof should be covered with felt.

The stiles and rails of the sashes should be prepared of $2\frac{1}{4}$-in. by $1\frac{1}{2}$-in. stuff, and the bars may be $1\frac{1}{2}$ in. by 1 in. The wood should be planed up, set out, mortised, tenoned and rebated. The kind of joints at each of the angles is shown by Fig. 21, and Fig. 22 illustrates the joint between the bars and rails. The sashes may be made fixtures, or hung at the top so as to open outwards at the bottom; or another good plan would be to make them slide. Fig. 23 shows the joint for the lower corners of the skylight, and Fig. 24 the joint of the bottom rail and bar of the skylight.

The two posts at each corner should be fixed together with two 6-in. bolts and

nuts. The bottom of the outside can be completed by a plinth.

The object of having the plate shown in Fig. 20 being in two parts is to allow of the roof being easily detached from the long side. Fig. 19 shows a rafter resting on a plate which can be fixed to the wall with two or three holdfasts. Should a back be necessary it would be advisable to have this plate in two halves similar to the front one, as in Fig. 20.

The following are the quantities of timber required: 38 ft. of 3-in. by 3-in. for the floor frame; 240 ft. of 3-in. by 2-in. for the joists, framing of sides and ends, and rafters; 156 ft. of $6\frac{1}{2}$-in. by $\frac{7}{8}$-in. prepared floorboards; 24 ft. of 3-in. by $1\frac{1}{2}$-in. for the top horizontal pieces of the side frame; 466 ft. of $\frac{3}{4}$-in. matchboarding; about 34 ft. of $1\frac{1}{2}$-in. by 9-in. board will be required for the sashes and skylight; and about 75 sq. ft. of felt for covering the roof.

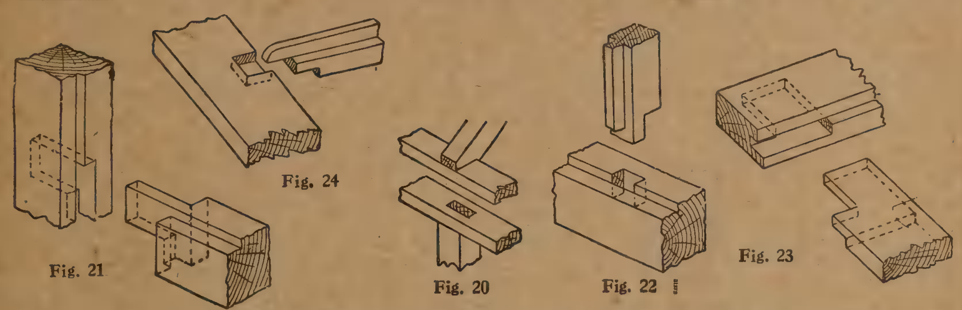
A Motor-cycle House.—The design for a motor-cycle house shown by Fig. 25 has been specially worked out to provide a roomy and portable erection, containing no difficult joints; each part is quite complete in itself and bolted together.

The framework is composed of either 2-in. by 2-in. or 2-in. by 1-in. batten, and is covered with $\frac{3}{4}$-in. matching. Beginning with the front frame as shown at Fig. 26, it will be seen that it is 7 ft. long and 5 ft. 6 in. high, the window space 3 ft. long by 1 ft. 9 in., the whole being of 2-in. by 1-in. batten.

First cut off three 7-ft. lengths, two 5-ft. 6-in. pieces for the end uprights, two 2-ft. 10-in. pieces for the sides of the window space, and one length 3 ft. 4 in. for the top of the latter space. Details of the necessary joints for connecting these pieces are shown by Fig. 27; A indicates the method of cutting the ends to make the corner joints, B the same joint completed, and C shows how the slot should be cut in the middle parts of the battens. The easiest way of cutting the joints is to mark a line along the middle on each edge, set off the length of the slot, 2 in., and then saw down to the middle line and chisel out the waste in the case of C; but in the joints at the end the whole of the waste may be sawn out. A tenon saw is most convenient to use; but there is no reason why a hand saw should not be used, although it does not give so neat a saw-cut across the grain.

Having cut all the joints, fix them together with $\frac{7}{8}$-in. screws, first making a hole in one piece with a bradawl or gimlet. The frame is now ready to be covered with tongued-and-grooved deal matchboarding, $\frac{3}{4}$ in. by 5 in.; but it will be advisable, in order to prevent waste in cutting up the matching, to cover all the frames when they are completed.

The back frame is shown by Fig. 28. It is composed of three 7-ft. lengths and two uprights each 6 ft. 10 in., all cut from 2-in. by 1-in. batten, with the joints as in the front frame. The principal point to



Figs. 20 to 24.—Joints in Workshop Framing, Sashes and Skylight

consider in making frames of this kind is to get all the pieces at right angles and parallel to each other, this being done by marking all the long lengths together, and the end uprights in the same way, so that there is no risk of them being different sizes, which might easily result if they were measured off separately.

The door end framing is shown by Fig. 29. The back upright is 7 ft. 1 in. by 2 in. by 2 in., the front 5 ft. 9 in., and the bottom 4 ft. 10 in., both pieces 2 in. by 2 in. The two rails at the top are of 2-in. by $1\frac{1}{4}$-in. batten, the sloping length being 5 ft. and the other 4 ft. 10 in. The 2-in. by 2-in. wood is halved together at the corners in the same way as the 2-in. by 1-in. stuff; but the $1\frac{1}{4}$-in. lengths should have half the thickness cut away, and the remaining portion let into the uprights from the back. This will bring the face within $\frac{3}{4}$ in. from the front of the uprights and allow the matching to be nailed flush with them; a section is shown at D (Fig. 27).

The closed end has the back upright 6 ft. 10 in. and the front upright 5 ft. 6 in., both of the 2-in. by 2-in. wood. The three straight rails are 4 ft. 10 in., the sloping piece 5 ft., these four pieces being of 2 in. by $1\frac{1}{4}$ in., and let in as indicated at D (Fig. 27). The floor framing is shown in half plan by Fig. 32. It is 6 ft. 10 in. by 5 ft., with two intermediate lengths of 5 ft., all of 2-in. by 2-in. wood, the corners and other joints being halved as before. The roof is framed up with 2-in. by 1-in. battens, as shown by one-half in Fig. 31. It will be seen that five rafters, each 6 ft., will be required, as well as two lengths each 8 ft. The pieces are joined edgewise, the correct slope being obtained by setting out the end full-size on the floor.

The framing may now be covered, the floor in the first instance being covered with ordinary 6-in. by 1-in. floorboards cut to lengths of 6 ft. $11\frac{1}{4}$ in. This will mean ten lengths placed flush with one end and projecting a distance of $1\frac{1}{4}$ in. at the other.

For the roof it will be necessary to cut off fifteen 8-ft. lengths of matching. Saw and plane one length to $3\frac{1}{2}$ in. wide, and nail it to the top; follow on with thirteen lengths, and then cut the last to $3\frac{1}{2}$ in. wide, and fit it in. In order to get the matching quite close together it will be necessary to cut a 12-in. or so length of the matching, and saw it down half-way. This piece should be placed in the groove to provide a piece on which to hammer, otherwise the edges of the matching would get damaged.

For the back, cut off seventeen 7-ft. 3-in. lengths, and cut the first to $4\frac{1}{2}$ in. wide, nailing it to project 2 in. at the top and 3 in. at the bottom. Continue with the others, and plane down the last one to the required width, probably $4\frac{1}{2}$ in.

The closed end will require eleven boards, the longest one being 7 ft. 3 in. and the shortest 6 ft., both these lengths being planed down one edge to fit between the uprights. The projection at the top is 2 in. and the bottom 3 in., as shown by the dotted lines at Fig. 31.

The front will take altogether seventeen boards, five at each end being 5 ft. 11 in. long, the end ones being planed to $4\frac{1}{2}$ in. wide on one edge. Seven lengths each 3 ft. 1 in. will be needed for the space under the window opening, and the same number of 11-in. lengths above it. The outside edges of the two boards adjoining the window opening should be trimmed to the edge of the upright pieces of the frame.

The upper portion of the door frame should be filled in with matching, eleven lengths varying from 2 ft. 1 in. to 9 in., projecting 2 in. at the top as shown by the dotted lines. Holes should now be bored through the sides in the position indicated by the bolt heads in the perspective view, and the position of the holes marked on the end pieces, so that they may be continued through. The distance from the edge, at the closed end, should be $1\frac{3}{8}$ in., and at the door end 1 in.

To place the sides together, first fit the closed end on the end of the floor and attach the front to it; next fit on the back, and then the door end. The roof may then be fitted on, first cutting slots in the front and back matching to take the three inner rafters. It will be seen

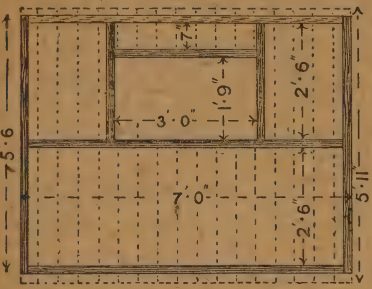
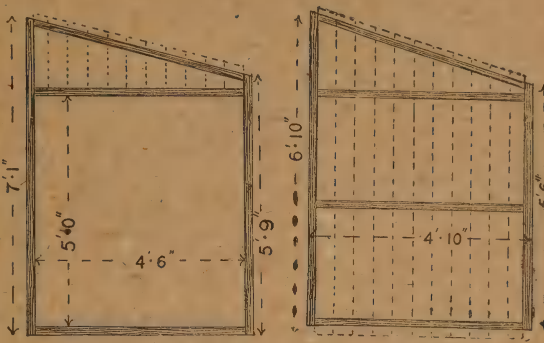


Fig. 26.—Front Framework of Motor-cycle House



Figs. 29 and 30.—Door End and Closed End Framework

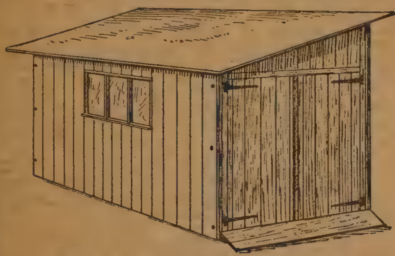


Fig. 25.—Motor-cycle House

Figs. 31 and 32—Roof and Floor Framework

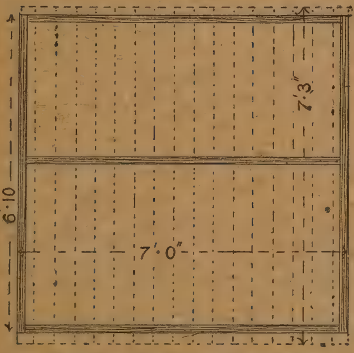


Fig. 28.—Back Framework

Fig. 33.—Inside Elevation of Door

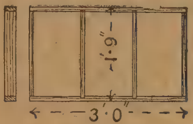


Fig. 34.—Window Frame

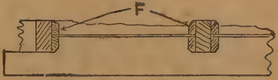


Fig. 36.—Glass in Window Frame

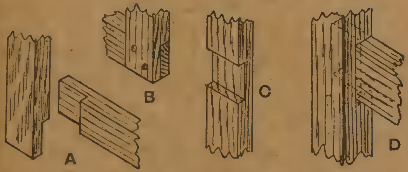


Fig. 27.—Framework Joints

Fig. 35.—Window Sill Detail

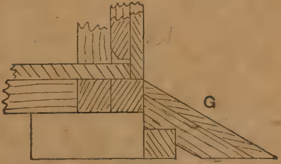


Fig. 37.—Detail of Floor Construction

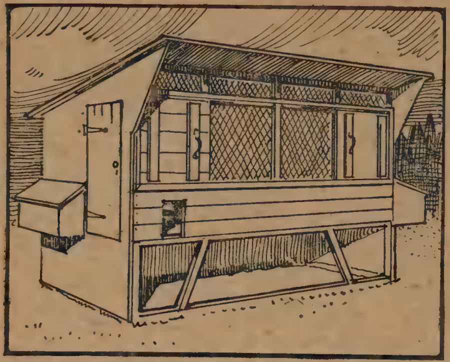
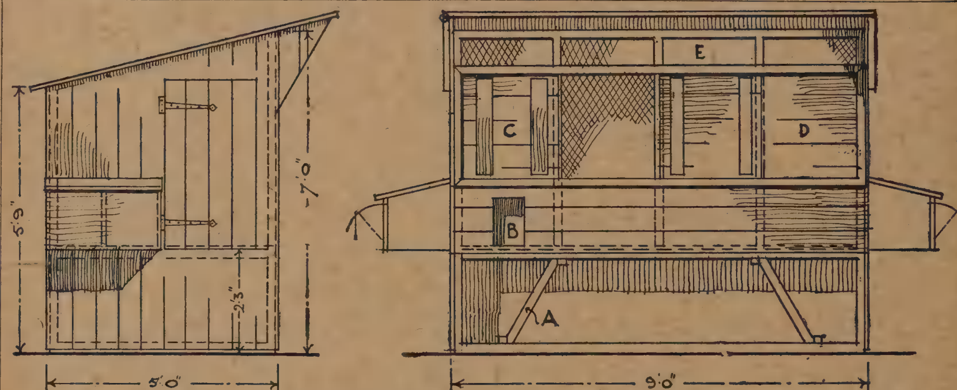


Fig. 38.—Poultry House with Run or Scratching Shed Underneath

that the two outside pieces, as well as the top and bottom pieces, fit outside the matching; this will allow of screws or bolts being fitted to hold the roof down. If the work fits together properly it may be taken apart and given at least three coats of good oil paint, and the roof covered with felt or some suitable roof covering.

The doors are each 5 ft. high and 2 ft. 3 in. wide, one being shown by Fig. 33. Cut off six 5-ft. lengths of matching for each and use three 2-ft. 2-in. lengths of 6-in. by 1-in. floorboard to form battens. The doors should be hung with cross-garnet hinges, and a front bead should be attached to one of the doors so as to cover the other $\frac{3}{4}$ in. or so when closed. Any suitable lock or other fastening may be fitted.

The window opening should be filled with a framing made of 2-in. by 1-in. batten as shown in Fig. 34, the wood being framed up edgewise, two lengths



Figs. 39 and 40.—End Elevation and Longitudinal Section Through Poultry House

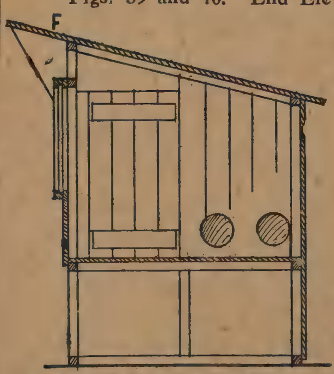


Fig. 41.—Cross Section Through Poultry House

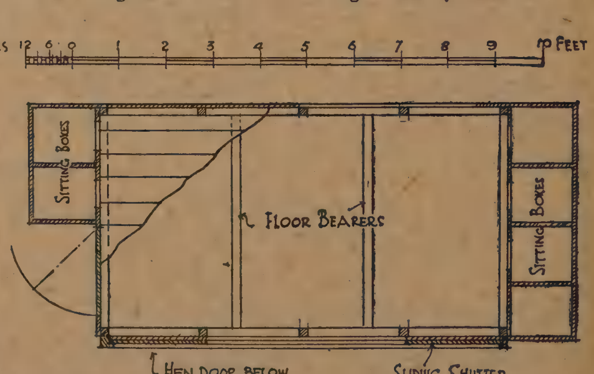


Fig. 42.—Horizontal Section Through Poultry House

each 3 ft., and four uprights 1 ft. 9 in., the two middle pieces being left in half the thickness of the wood and the ends nailed together. The bottom piece would be better if made as shown at E (Fig. 35), and in this case should be $3\frac{1}{2}$ in. wide and 1 in. thick. The glass may be kept in position by means of $\frac{7}{8}$-in. by $\frac{1}{2}$-in. wood fillets nailed on as shown in horizontal section at F (Fig. 36).

A strip of $1\frac{1}{4}$-in. by $\frac{3}{4}$-in. wood should be nailed at the top of the door framing to act as a stop for the door, and a slope provided as indicated at G (Fig. 37); this should be made of a length of 2 in. by 2 in., with three or four pieces placed at the required angle and covered with floorboard.

When the sections are all ready to put together in the proper place, the floor should be placed in position and stood on tarred sleepers or rows of bricks, so as to raise it a few inches from the ground. The sides and roof may then be bolted together, and the construction of the house will be complete.

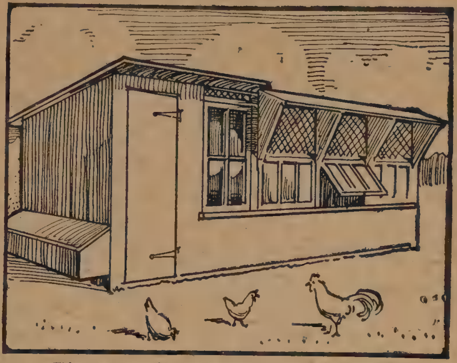


Fig. 43.—A Larger Poultry House

Below is given a specification of the quantities:

Two squares tongued-and-grooved matching, 5 in. by $\frac{3}{4}$ in.
42 sq. ft. tongued-and-grooved floorboard, 6 in. by 1 in.
136 ft. run deal batten, 2 in. by 1 in.
25 ft. run deal batten, 2 in. by $1\frac{1}{4}$ in.
70 ft. run deal batten, 2 in. by 2 in.
6 yd. roofing felt; bolts, paint, glass, etc.

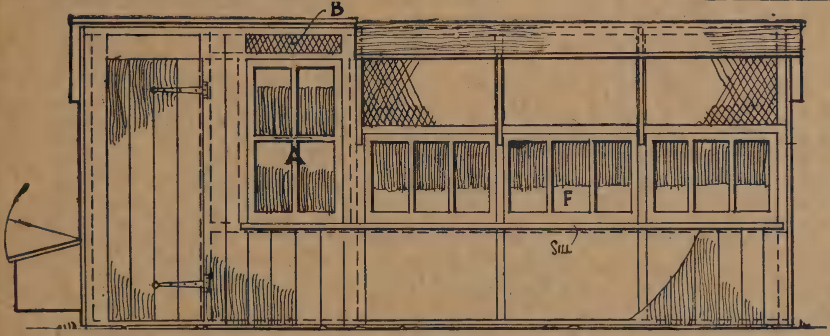


Fig. 44.—Front Elevation of the Larger Poultry House

Fig. 45.—Horizontal Section Through Poultry House

TWO POULTRY HOUSES

First Example.—In the house shown by Figs. 38 to 42 a covered run is provided under the hen roost. The house is drawn to the size of 9 ft. by 5 ft., and if built to these dimensions would accommodate comfortably from twenty to thirty fowls, but it could easily be made larger. The arrangement of the framework will be gathered from the scale drawings, the plan showing the positions of the uprights as well as of two intermediate bearers used to stiffen the floor. The boards of the latter run longitudinally. Two sloping struts will be required to stiffen the front rail, as at A, and can be framed in position, or secured with small blocks or cleats as shown. A hen-door with sloping plank is required at B, above which an arrangement of sliding ledged shutters is employed whereby the centre of the front can be thrown entirely open or wholly or partially closed at will. At C is the left-hand shutter fully open, and at D the right-hand one completely closed. Above these again, at E, is a narrow continuous ventilating strip, permanently open and sheltered by the projected boarding of the roof, as at F, and also by the triangular pieces at the ends, seen in Fig. 38. At one end the door leaves room for two projecting sitting-boxes, but at the other end is room for four more.

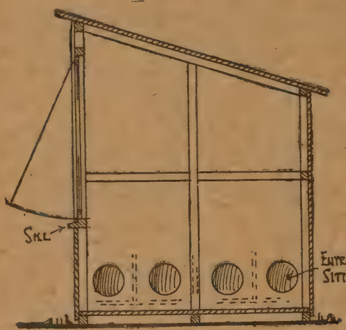


Fig. 46

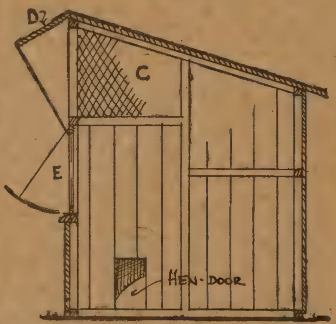


Fig. 47

Figs. 46 and 47.—Cross Section and End Elevation of the Larger Poultry House

Second Example.—The house shown in Figs. 43 to 47 has, in addition to a roosting house measuring 5 ft. × 6 ft., a scratching shed the same size as the house already described. The house is of a type particularly adapted to exposed positions, and consists of a roost complete with projecting sitting-boxes, connected with a larger scratching shed, beyond which an open run can be arranged. While the roost can advantageously have a boarded floor, the outer compartment should be open to the earth. The roost has an attendant's door on the front, and also a large glazed window, as at A, hinged at the top to open outwards and adjusted by means of a casement stay at the bottom. Above the window will be noticed a small wire strip, B, permanently open for ventilation, which is further provided for by means of the panel of wire in the side next the scratching compartment, shown at C. The front elevation will best serve to explain the arrangement of the scratching shed, which can have an open outer end if not too exposed, but would otherwise be entirely boarded in on the back and end. Its roof slopes to the back, but finishes in the front with a sloping hood projecting 15 in. or 18 in., as at D, and supported on triangular brackets, as shown. Beneath this hood and sheltered by it are open panels of wire netting, below which is a horizontal rail to which are hinged small glazed lights, as at E and F. Below these is a projecting piece to serve as a sill, and the remainder of the front is filled in with boarding as indicated.

AN INTENSIVE POULTRY HOUSE

Much has been heard in recent years of the intensive system of keeping poultry.

This is a system by which the birds are generally confined to their houses, and is particularly suitable where room is restricted. As an experimental intensive house, almost any structure with a sound roof and sides that will keep out rain can be used; but for keeping birds on this system for any length of time it is better to have a house especially designed and built for the purpose.

The first principle is to keep out damp; the droppings, etc., are not injurious so long as they are dry, but immediately rain gets to them they emit ammonia and other noxious vapours which seriously interfere with the health of the birds. The second principle is so to construct the house that the birds can be provided with plenty to do—in other words, the design of the house must allow of a very deep layer of litter being spread over the floor. The birds are fed on dry food—as much grain as possible—and this is thrown into the litter and raked in so that the birds have to keep on the scratch for their food. Another principle that must be observed is that there should be a droppings board under the roosting perch, which board should slide or lift easily in and out. Still another principle is that the nesting boxes should not have the full light of day upon them and that they should be above the level of the litter, and constructed in such a way that the eggs cannot be scraped out into the litter.

Birds kept on this system will be found o consume a great deal of water and grit; vessels must therefore be provided well above the level of the litter, and it is desirable to see that the birds cannot easily throw the water about into the litter.

The poultry-keeper can very largely please himself as to the design and construction of his houses so long as he observes these points, but a good idea of usual construction is given by Figs. 48 to 51. This is a comparatively small house (7 ft. by 10 ft.), accommodating not more than twenty birds. A safe allowance is 4 sq. ft. per adult bird. It constitutes a type of house suitable for adaptation to any size, it being borne in mind that whereas an old-style house could be long and fairly narrow, a square form is better for those destined for the intensive system. Thus 6 ft. by 5 ft., 8 ft. by 6 ft., 10 ft. by 7 ft., 12 ft. by 10 ft., 16 ft. by 12 ft., or 20 ft. by 16 ft. are all suitable proportions of length to width.

This intensive house provides plenty of light and air, and can be built with or without projecting sitting boxes. The bottom of the front is boarded, but above this there is an horizontal rail dividing the front into upper and lower panels of wire mesh, which should be fixed on the inside. When necessary, the top row of panels can be closed by letting down the sloping hood, which is strongly hinged at the top and supported in its raised position by a couple of stout struts hinged to the corner posts of the house. Slots can easily be contrived for their free ends on the underside of the hood, so that it will not be allowed to slip down, and the hood itself can be made up of light boarding held together with cross ledges at intervals. It is, of course, just the right width to cover the top panels when the struts are let down. The lower panels of the front require light frames, covered with linen and fitting between the posts and rails. When these are required they can be kept in place with wood buttons or turn buckles, as indicated on the drawings.

Internally a boarded floor is very desirable, and either an ordinary droppings board or a range of boxes can be fitted up.

It should be understood that the floor of the house must be very deeply covered with litter, for which many different materials are available. In country districts the threshing of various kinds of corn will provide vast quantities of material in the form of husk, etc., that can be had almost for the asking. The dry, mealy stuff to be found under gorse bushes also makes a good litter. Sawdust has been very strongly recommended, but an objection to it is that it is not ideal stuff to dig into most garden soils. Any perfectly dry earth will answer. Leaves collected in the autumn and stacked until they are quite dry have been found to give every satisfaction. The cheaper and, perhaps,

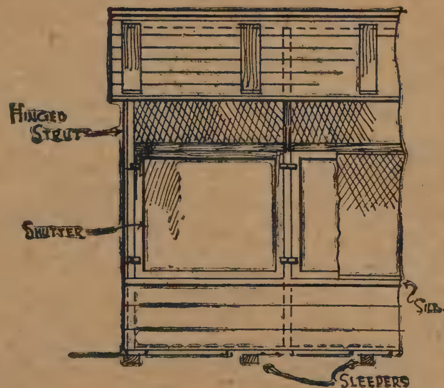


Fig. 49.—Part Elevation of Intensive House

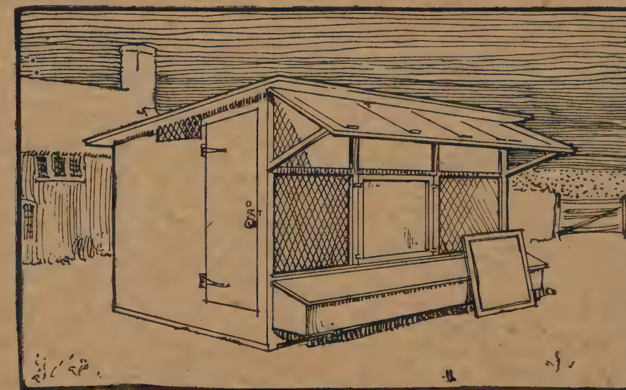


Fig. 48.—A Small Intensive-system Poultry House

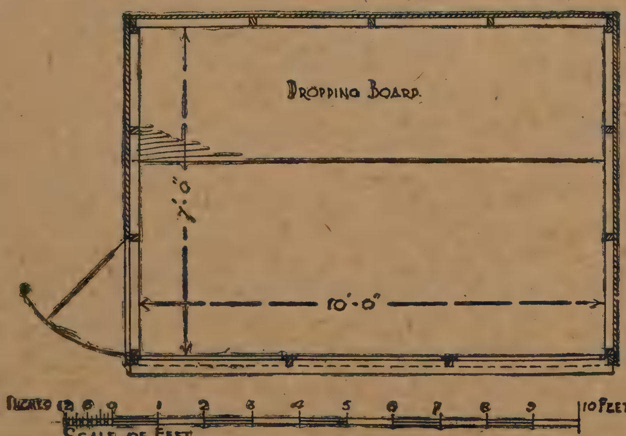


Fig. 50.—Horizontal Section Through Intensive House

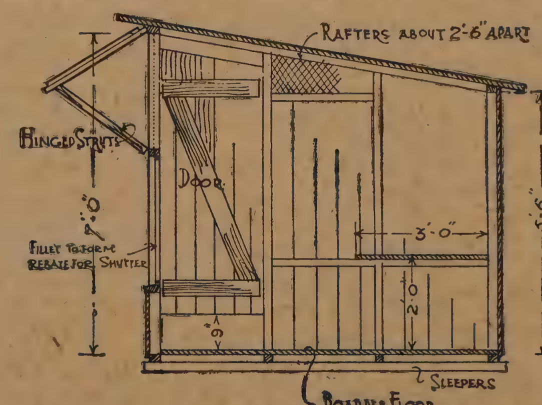


Fig. 51.—Cross Section Through Intensive House

spoiled quantities of straw and hay are also excellent. The litter will not need changing very often as long as the house is of proper design and construction.

TARRING POULTRY-HOUSES, ETC.

For the outsides of poultry-houses, etc., tar is preferable to paint, since, while it is quite as rainproof, it is considerably cheaper. It is much improved, however, by the addition of a little paraffin or naphtha. To prepare for use, heat 1 gal. of ordinary gas tar in an old pail, in the open air if possible; if heated indoors, great care must be taken that the stuff does not boil over, as it is highly inflammable. When warm, add $\frac{1}{4}$ lb. of russian tallow, and stir well in. Take the tar off the fire, and add 1 pt. to $1\frac{1}{2}$ pt. of paraffin oil or naphtha. Mix thoroughly, and apply hot with an ordinary tar brush. The addition of a little red ochre, well mixed in, will turn the stuff a rich chocolate tint, which may be preferred to the black. Tar-felted roofs thus treated should be sprinkled with silver sand.

The addition of the paraffin oil makes the tar penetrate well into the wood, and also causes it to harden much more quickly; but, nevertheless, it is well not to commence operations unless warm, dry weather can be relied on for a day or two.

LIMEWHITING POULTRY-HOUSES

Before limewhiting, the soiled walls of a poultry house should be washed down with a strong solution of soda, soft soap, and water. This done, the inside woodwork should be well sprayed with a strong disinfectant, one of the best being carbolic acid, diluted with water in the proportion of about 1 in 40. An ordinary garden syringe or sprayer suits the purpose admirably. Special care should be taken to send the disinfectant well into all seams, joints, and crevices.

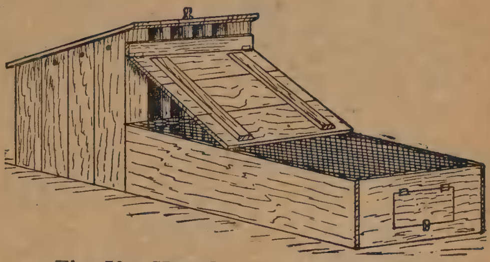
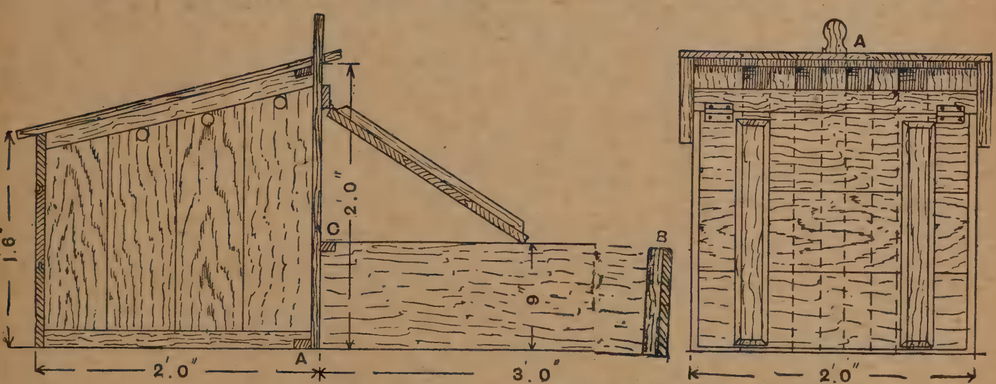


Fig. 52.—Hen Coop with Chicken Run



Figs. 53 and 54.—Elevations of Coop and Run

When the wood is dry again, treat thoroughly with a coat of limewash made as follows: Put $\frac{1}{2}$ bushel of quicklime into a water-tight barrel; pour on boiling water until covered 4 in. or 5 in. deep, and stir till the lime is slaked. Then dissolve in water 1 lb. of common salt and 2 lb. of sulphate of zinc, and mix the solution well into the lime. This causes the limewash to harden on the woodwork. Stir well, and add more water if necessary to give the consistency of cream, and apply with a whitewash brush.

The ends of perches should be dipped in

paraffin oil, as otherwise they harbour insect pests, and the perches themselves may be brushed over with the paraffin oil to prevent insects from hiding in cracks and crevices.

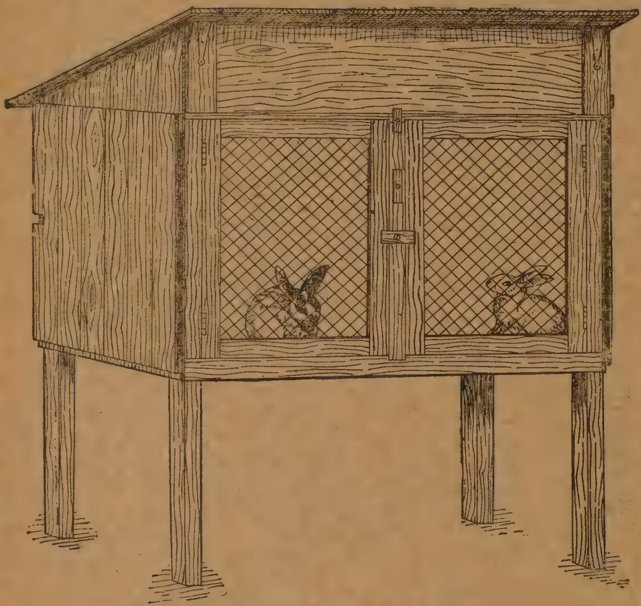


Fig. 55.—Two-compartment Rabbit Hutch

A HEN COOP WITH CHICKEN RUN

The coop shown by Fig. 52 is intended for use in rearing early chickens, and fitted to the front is a hinged flap which may be allowed to rest on the top of the run to shelter it partially during the daytime as shown, or it may be lifted higher and secured with a hook and staple. At night the run may be removed and the flap let down to keep the brood warm and ward off cats and rats. If the latter are troublesome, the holes over the flap may be covered with wire netting.

To make the coop, first prepare the boards to form the sides, then put them together and nail them to ledges of $1\frac{1}{2}$-in. by $\frac{3}{4}$-in. stuff, as shown at the top and bottom of Fig. 53. Sound $\frac{3}{4}$-in. deal should be used throughout, and the joints of the boards should be tongued-and-grooved for the sheeting. Next nail on the boards to form the back, putting a strip up the corners if necessary, and get out a rail, A, 2 in. by $\frac{3}{4}$ in., notching it for the front rails to fit in at the bottom and secure it at the sides. Fit another rail across the top as shown, then put on the roof. Next fit up the front (Fig. 54), mortising the middle rail A through the roof to allow of its being lifted to release the hen. Make the hinged flap for the front by cutting three or four boards to length and cross battening them with a couple of ledges; then prepare a rail 2 ft. long by $1\frac{1}{2}$ in. by $\frac{3}{4}$ in., and secure the flap to this, with a pair of butt or tee hinges. This rail should be secured to the front of the coop with screws, so that it can easily be removed with the flap.

Fig. 56.—Front Elevation of Hutch, with Loft Door Open and Shutters Closed

The run can be made by cutting two 9-in. or 10-in. boards 3 ft. or more long to form the sides, and a piece 1 ft. $10\frac{1}{2}$ in. by 9 in. wide for the front. Upright pieces may be nailed on to strengthen the corners B, and a cross rail C must be used at the side against the front of the coop to carry the wire netting. A hinged flap at the front end of the run will be found useful for supplying soft food and water for the chickens, and the top of the run may be covered with $\frac{3}{4}$-in. or 1-in. mesh wire netting, secured to the sides and ends with small staples. A few centre-bit holes may be bored in the coop through the top of the sides to ensure thorough ventilation.

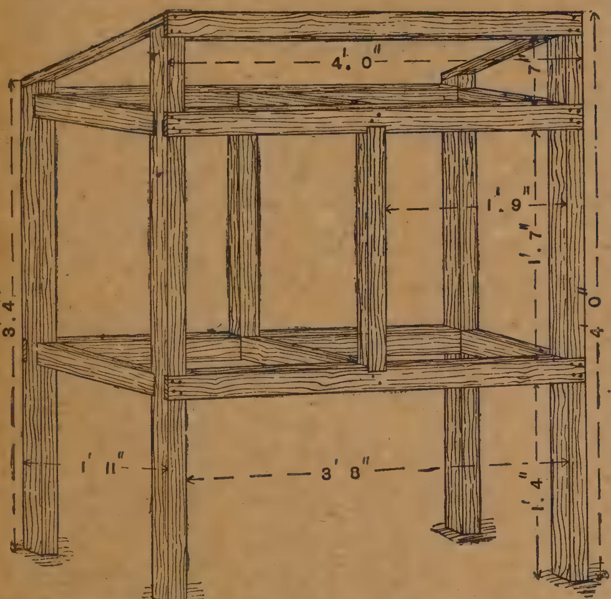


Fig. 57.—Framework of Hutch

A TWO-COMPARTMENT RABBIT HUTCH

A comfortable hutch that would be suitable for breeding rabbits is shown by Fig. 55. It has two compartments, with doors panelled with wire netting, and a slanting roof so that the rain can run off freely behind. A loft is made of the upper part, opening at the front, for holding a supply of hay or straw for bedding. The hutch is also provided with outer doors or shutters, to close at night or in severe weather. Fig. 56 is a view of the front, with the loft door open and shutters closed. The timber required is as follows: 54 ft. of 2-in. square scantling; 20 ft. of 2-in. by 1-in. scantling; 120 ft. of $\frac{1}{2}$-in. tongued-and-grooved board (sometimes termed matchboard) 6 in. wide. In some cases

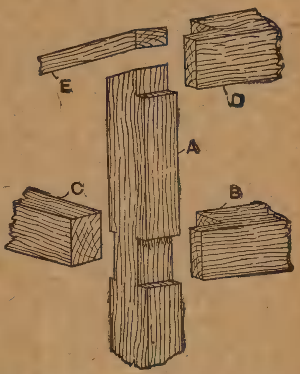


Fig. 58.—Fixing Rails to Upright


Fig. 61.—Method of Holding Shutters When Open

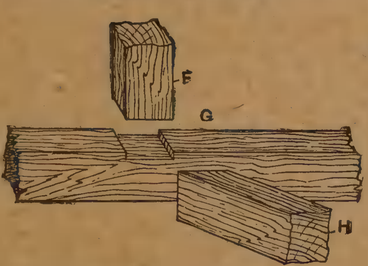


Fig. 59.—Fixing Division Pieces to Rail

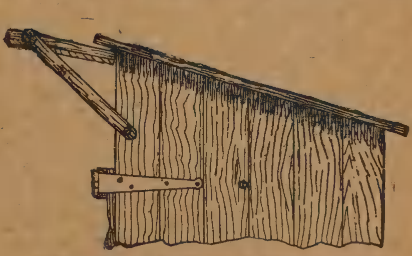


Fig. 60.—Method of Propping-up Loft Door

timber is sold per square foot, but the measurements here given are per foot run, which means taking it at its width. It is as well to keep the timber for a week or two in a dry place before using, to allow it to shrink.

The framework (see Fig. 57) is first built up, with the 2-in. square scantling, to the dimensions given. The two front uprights, 4 ft. long, and the two back uprights, 3 ft. 4 in., are cut first; then five rails 4 ft. long, and four 1 ft. 7½ in. The method of jointing is shown in Fig. 58. A is the upper portion of the left-hand front upright, B the end of the second long rail, C the end of the short rail, D the top long rail, and E the top short rail. The front uprights are cut on the front side, 1 ft. 4 in. from the lower end, ½ in. deep, to the width of the rails, the waste being chiselled out; and the rail is then cut to fit. The other rail is fitted, 1 ft. 7 in. above it, in the same way. Two more are joined in the same position to the back uprights. The long rails must not be fixed until the four side rails have been fitted; the ends of these are quite square, and are let into the uprights ¼ in. deep, to correspond with the long rails. When they are tightly fitted they must be nailed with 3-in. cut nails, two to each joint, first piercing with a suitable sprig bit to avoid splitting. The two ends of the framework may now be stood up 4 ft. apart with the back uprights to the ground, and the two long front rails nailed in place; they are then turned over, and the back rails fixed in the same way.

The frame may now be stood upright, and the two division pieces cut, 1 ft. 7½ in. long, and fitted midway by letting the ends into the rails, as shown in Fig. 59, where F is the division piece, G the lower back rail, and H the crosspiece, which is simply cut to fit tight between the two lower rails, then secured with long nails, a similar piece being fitted between the upper rails. The top ends of the uprights will require to be cut on the slant for the two sloping side rails, which are cut from the 2-in. by 1-in. stuff and nailed on. When this has been done, the top of the front uprights must be cut out, to take the top long rail, as shown in Fig. 58. A strip must be nailed along the top back rail to bring it up flush for fixing on the roof.

The frame is now ready for boarding, the sides being done first. The boards should be cut one at a time, and nailed to all three rails, and should be fitted together as tight as possible. The partition is made by nailing the boards to the two inner rails vertically. Next the floors should be laid, the boards being fixed on the upper side of the lower rails, flush at the back, but 1 in. from the front, and running from back to front. The ceiling is done in the same way on the under-side of the upper rails, so as to give more space to the loft. The sloping boards of the roof are next put on, and should overhang 2 in. all round at the least. The back boards are put on vertically, like the sides.

For the doors, four pieces of the 2-in. by 1-in. stuff, 1 ft. 7 in. long, will be required, and four pieces 1 ft. 9 in. long; these should be planed up and made into the frames, the joints being simply halved, glued and screwed. The doors should be made to fit neatly but free, and hinged with 2-in. iron butt hinges, which must be let into the frames flush about 3 in. from the corners, with the round standing out. Some wire netting of about 1½ in. mesh is fixed over the frames inside with large-head tacks or small staples, thin laths of wood being nailed over to cover the ends of the wire. Now place the doors in with the hinges folded, mark the uprights, and hinge on. They are kept shut with a wood button, the lowest of the three shown in Figs. 55 and 56.

To make the loft door, a board the full length of the hutch, and 9½ in. wide by ½ in. thick, must be got out, and two battens nailed on at the extreme ends, on the outside. It is then hinged under the overhanging part of the roof with 5-in. T-hinges, and is kept closed by a button as shown, which will require a piece of ½-in. board fixed under it. A device for propping it open is shown in Fig. 60. A strip of wood 1 ft. 1 in. by 1½ in. by 1 in. has one end screwed tight to the batten 2½ in. from the corner; a screw is put in

the side as shown, and a hole made at the end of the prop large enough to pass over the screw-head. Another screw is put in farther back to take the prop when the loft is closed. It is a good plan to bore a number of small drainage holes in the bottom of the hutch, and air-holes should be made at the back as high as possible, and at the tops of the sides, to air the loft.

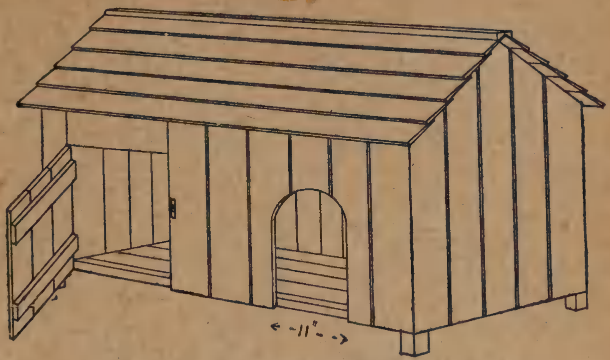


Fig. 62.—Two-compartment Dog-kennel

The outer doors or shutters are made by cutting the required number of boards 1 ft. 9½ in. long; these are held together by battens, and hinged on with 10-in. back-lap strap hinges. It will be necessary to cut pieces out of the end boards to clear the button of the inner doors when closed. They are kept shut by the middle button, which requires a piece of ½-in. stuff behind it, and held open by hooks placed at the back of the hutch, as shown in Fig. 61, the eyes being fixed to the top battens of the shutters.

The inside of the hutch should be lime-washed, and the outside given two or three coats of dark-green or any other colour paint, which will assist in rendering the hutch waterproof.

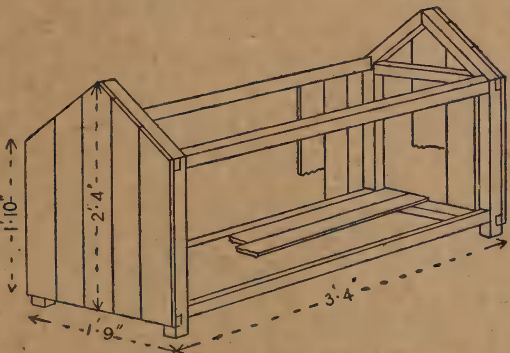


Fig 63.—Framework of Kennel

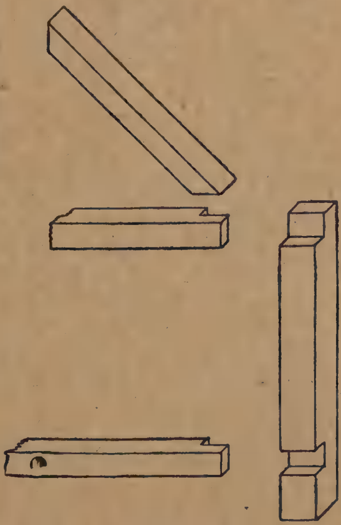


Fig. 64.—Joints in Kennel Framework

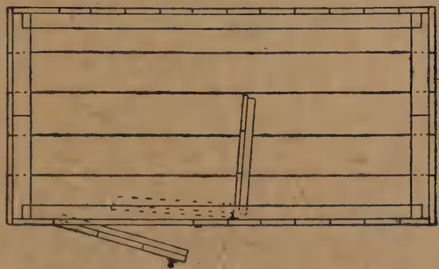


Fig. 65.—Plan of Kennel (without Roof)

TWO-COMPARTMENT DOG-KENNEL

For the kennel illustrated by Fig. 62 deal matching $\frac{3}{4}$ in. thick, afterwards well painted, is the most suitable boarding to use. The tongue-and-groove joints allow for any shrinkage or expansion of the boarding, and keep the kennel weather-tight from rain and draughts. Matching having a **V**-joint should be chosen, and narrow battens of 5 in. or 7 in. wide are more suitable than the wider boards.

When using boards for external purposes, they should be fixed so that the rain cannot penetrate in the joints, and if the matching is fixed horizontally, the tongue should be on the upper edge and the groove on the lower edge of the board; but it is generally the better plan to arrange the boarding vertically as shown in Fig. 62.

Feather-edge boards are, of course, an exception. These are always fixed horizontally, being made rainproof by one lapping over the other as shown for the roof of the kennel. The floorboards should be arranged 2 in. or 3 in. above the ground, to prevent the dampness rising, and two or three slots should be made in the floor for drainage when cleaning. Fig. 63 shows the framing. The four corner posts are 2 in. square, and all the other pieces $1\frac{1}{2}$ in. square. The joints are chiefly lapped as shown on the end frames, and the four long rails are secured with long screws through these joints on to the ends of the rails. The top pieces are simply splayed and nailed. Fig. 64 shows the method of making the joints before fixing together. Now fit and fasten with nails the back and the end boards, as indicated in Fig. 63, leaving the front open. Then fit in half of the front, and mark the entrance or doorway with the compasses and straight-edge. Take apart and cut to the shape with a bow-saw and spokeshave; then refix.

The door made of matching fastened with battens as in Fig. 62 shuts against the bottom rail of the kennel, and is fastened with a button. It is arranged to hinge on to a piece of matchboarding nailed on at the end of the kennel, and another piece 2 in. or 3 in. wide is fixed above the door and flush with the boarding. The floorboards, $\frac{3}{4}$ in. thick, are fixed lengthwise, so that the ends can be nailed to the lower rails of the end frames (see Fig. 63). The arrangement for a partial compartment is then made by hinging on a partition constructed the same as the door. It is fastened with butt hinges, and swings out of the way against the outer door when not required. A small bolt is fastened on so as to fix the partition to the floor when required.

Fig. 65 shows the plan of the kennel before the roof is nailed on, with the partition as required, or swung back out of the way. The feather-edge boarding for the top is cut so as to overhang 3 in. at each end. The lower boards, which overhang about 2 in. at the front and back, are nailed on first, and the other boards overlap about 1 in. or more until the top is reached. Allow the two top boards to butt one on the other, and fasten with brads. A piece of wood is then rebated to fit, and nailed along the top.

Methods of Cleaning Furs

As a rule, furs are cleaned by first rubbing in, and afterwards shaking out, some dry powdery substance. Here are two good methods :—

(1) Rub with *hot* roasted bran, allowing the bran to enter the fur well. Then shake the fur and well brush.

(2) Mix and heat in an oven equal parts of flour and fine salt, and thoroughly rub the hot mixture into the roots of the fur. Now well shake the fur, then throw it over the back of a chair, fur side upwards, and brush out any of the mixture left, using the end of a soft brush, and giving sharp "dabs" so as to get to the bottom of the channel formed by the parting of the fur, blowing well all the time.

A Simple Telephone Installation

How the Telephone Works.—"The telephone transmitter," as has been well explained, "has its nature based upon the requirements of an acoustic electric system. The general idea underlying all the operations in telephony is that of receiving the air vibrations, reproducing them as far as possible in the form of electricity, sending them over the wire as a set of electric undulations, and finally turning the electric undulations into sound waves by means of the telephone receiver. The theory upon which the transmitter operates is that of the effect of mechanical pressure upon a small block of carbon. The mechanical pressure is obtained by means of a thin sheet of iron called a diaphragm, which is so mounted as to compress delicately and irregularly a carbon button at its centre. The diaphragm is of the thickness of the iron plates used in the ferrotype process of photography, and when the human voice is concentrated by means of an appropriate mouthpiece to play upon it, the air vibrations or air waves beat upon the diaphragm with varying degrees of pressure, which, being conveyed to the carbon button, compress it with great rapidity to an infinitesimal degree each instant. The resistance of the carbon changes with each variation in the mechanical pressure caused by the voice waves. These changes are the cause of corresponding waves or undulations in the current passing through the carbon button, and their detection is best accomplished by means of the receiver. In other words, the transmitter is a device in which the human voice causes a carbon button to increase and decrease in resistance, and a uniform current passing through this button at the time will have its strength increased to an infinitesimal extent when the diaphragm presses against it due to the impact of an air wave. A current is therefore always passing through the transmitter when it is in use; and its delicacy and faithfulness in reproducing the air waves impinging upon it, in the form of electrical undulations, depend upon the adjustment between the diaphragm and carbon button."

Room-to-room Telephone. — This short chapter will deal with the small telephones suitable for communication between two rooms in a house, or between a house and a garden workshop. Probably the simplest and cheapest telephone is the ordinary Bell receiver (Fig. 1), which may be used both as receiver and as transmitter over a short line; this may be worked without a battery, as the action is magnetic, the instruments being furnished with permanent magnets. This is a type of instrument in which there is no induction coil. A length of twin No. 22 electric bell conductor is led from room to room, the two wires at one end being connected to the two screws on one instrument, and the two wires at the other end to the other instrument. The reproduction of the voice is not very

strong, and an auxiliary method of calling attention, such as an electric bell, is required.

Another form of magnetic telephone called the watch receiver (Fig. 2) may be used instead of the Bell telephone. A ceiving is combined in one instrument; and two of these instruments can be worked in connection with an existing electric-bell installation. A cheaper form of this combination for connecting to existing electric-bell installations is

Fig. 1.—Bell's Receiver

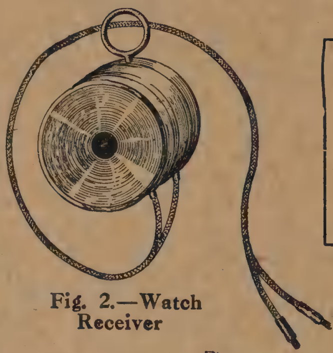


Fig. 2.—Watch Receiver

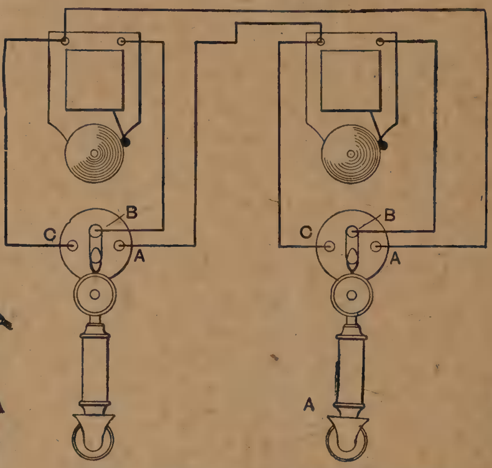


Fig. 4.—Wiring for Micro-telephone and Bells

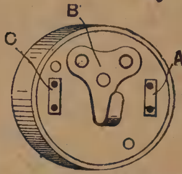


Fig. 5.—Block and Hook

Fig. 3.—Micro-telephone

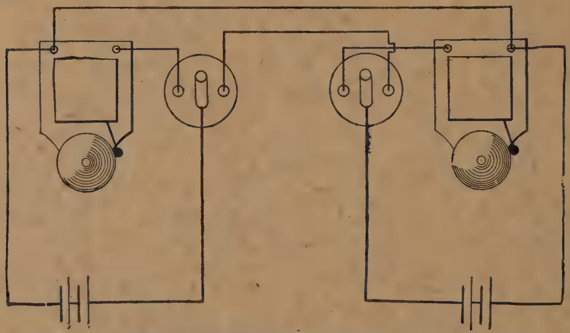


Fig. 6.—Wiring for Domestic Telephone and Bells, when Using Hook Switch-block

pair of either of these instruments must be employed, and for convenience of speaking and listening without removing the instrument from the ear, a pair of instruments is often employed at both ends of the line.

In the micro-telephone (Fig. 3), the arrangement for transmitting and re- shown in Fig. 4, a hardwood block with a hook switch arrangement (see Fig. 5) being used with these telephones. To connect them with an existing electric-bell system, detach one of the line wires from the bell and connect it to A on the switch-block. Then connect a short piece of bell wire to the terminal of the bell

from which the line was taken, and connect this short wire to B. Then connect the other terminal of the bell by means of another short wire to C. When the telephone is on the hook, the bell at the other station can be rung by pressing the ordinary push; but the telephone is, of course, taken off the hook when speaking.

Fig. 6 shows how these small domestic telephones may be connected to bells and batteries when using a hook switch - block. It must be noted that the hooks are connected to opposite terminals of the batteries—one to the carbon, the other to the zinc.

If there is no electric-bell installation it may be advisable to purchase a better class of instrument, with transmitter, receiver and bell complete.

Fig. 7 shows a kitchen metaphone complete. The rosette R contains a device for cutting in or out the metaphone, which is connected to the usual electric-bell system. When the metaphone is on the hook H, the conductors A and B are short-circuited. When the metaphone is removed, the hook rises, removing the short-circuit and joining the metaphone in series with the conductors A and B, so completing the speaking conditions. As regards the connecting up of this set all that is necessary is to open the battery lead at a convenient point, say X in Fig. 8, and join on the conductors A and B, as shown by the dotted line, R indicating the rosette as in Fig. 7. There is no need to interfere with the internal wiring of

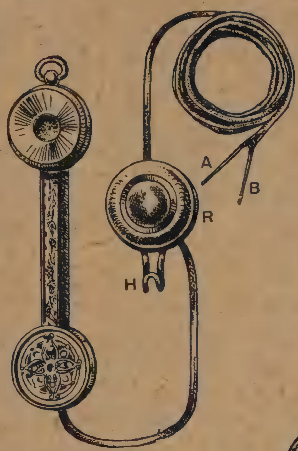


Fig. 7.—Kitchen Metaphone

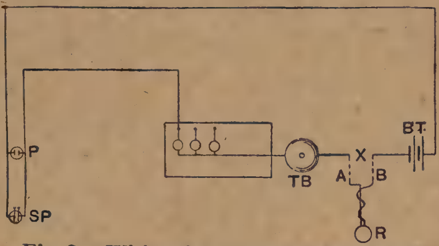


Fig. 8.—Wiring for Kitchen Metaphone

Fig. 10.—Push with Two-hole Contact

Figs. 11 and 12.—Connecting Domestic Telephone to Bell Push

Fig. 9.—Portable Metaphone

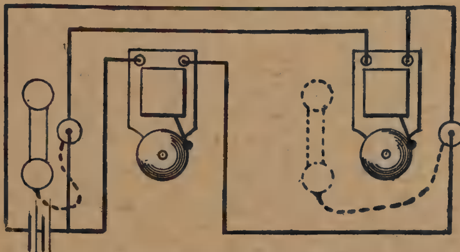


Fig. 13.—Another Combined Telephone and Bell Wiring Diagram

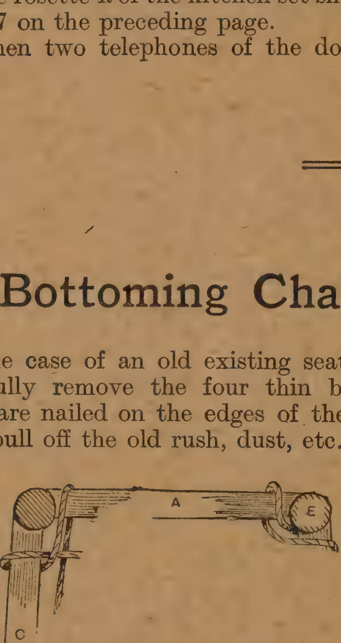
the indicator board shown to the left of the trembling bell T B.

The portable metaphone (Fig. 9) is provided with a two-pin plug P. To receive this plug P, special pushes (Fig. 10), provided with two-hole contacts C, should be fitted in place of the ordinary pushes in those rooms in which it is desired to use the portable metaphone. Fig. 8 has been drawn to show the wiring for the kitchen set and the dining-room pushes, the push P being an ordinary push, and S P a special push, as Fig. 10. B T is a two- or three-cell Leclanché battery, T B trembler bell, A and B the conductor to the rosette R of the kitchen set shown in Fig. 7 on the preceding page.

When two telephones of the domestic pattern, with transmitter, microphone and receiver combined in a handy form, with a contact stud in each handle, are to be connected to an electric-bell system at the pushes, all that is necessary is to connect the two tags of the flexible cord on each instrument to the springs in each of the pushes, as shown in Figs. 11 and 12. (This may be done by passing the tags through the same holes as the bell wires.) The calls may then be made by pressing the bell-push buttons, and subsequent conversation can be carried on by pressing the studs in the telephone handles, as shown in the diagram (Fig. 13). A small brass hook attached to the lower rim of each push can be used as a support to the telephone.

Bottoming Chairs with Rush or Cord

In the case of an old existing seat, first carefully remove the four thin battens that are nailed on the edges of the seat, and pull off the old rush, dust, etc. The



sides [illegible]
below the corners, [illegible]
flush with the corners

The work proceeds from one regularly round to others in succession, ending in the centre, so that all four sides are worked together, as shown in the accompanying illustration, in which A, B, C, D are the sides of the seat frame. Have a good coil of cord on a stick, and make the end fast to the leg E (right-hand back corner), pass the coil up and out over A, then up and out over B over C and up and
[illegible] er A, then over D and up and out
[illegible], etc. This will be quite clear from
[illegible] ord shown in the illustration here-
[illegible] When pulled up snug and tight,
[illegible] s the work proceeds, it will have the
[illegible] arance at each corner of that at the
[illegible] er E.

[illegible] ny joining of the cord or rushes must, [illegible] course, be done after a back turn, so [illegible] t it will come underneath.

Stuffing can be pushed in between the [illegible] pper and lower layers of cord as the work [illegible] roceeds, and the end which is first [illegible] itched to the leg can be knotted and [illegible] fterwards cut off.

Motor-car Overhaul and Adjustment

THE instructions given in this chapter cover in detail the overhauling of any kind of petrol motor-car, and will be the more easily understood after careful study of Figs. 1 to 9, which illustrate the elements and mechanism of a four-cylinder light car. The real art of overhauling mechanism lies as much in what is left undone as in what is done. This is particularly true of car overhauling, because the conditions of working on the road so frequently make it very difficult for even the most practised driver or mechanic to form definite and correct ideas of what is required.

But even if the amateur lacks the experience of the accomplished tester, he can go a long way towards obviating unnecessary work by reducing the overhauling to a system which recognises the necessity for first knowing what has to be done before starting work. Overhauling, in its right sense, is not altogether a matter of taking the car to pieces; it is very largely a matter of inspection. A careful examination of the car to begin with will more than pay for the time involved. Great care, however, must be taken in first finding out what the trouble is, as incorrect diagnosis may lead to a vast amount of unprofitable labour.

Wherever parts are worn sufficiently to justify their renewal, it will be advisable to obtain the spares as far as possible from the makers, as they have facilities for producing them in quantity from the most suitable materials.

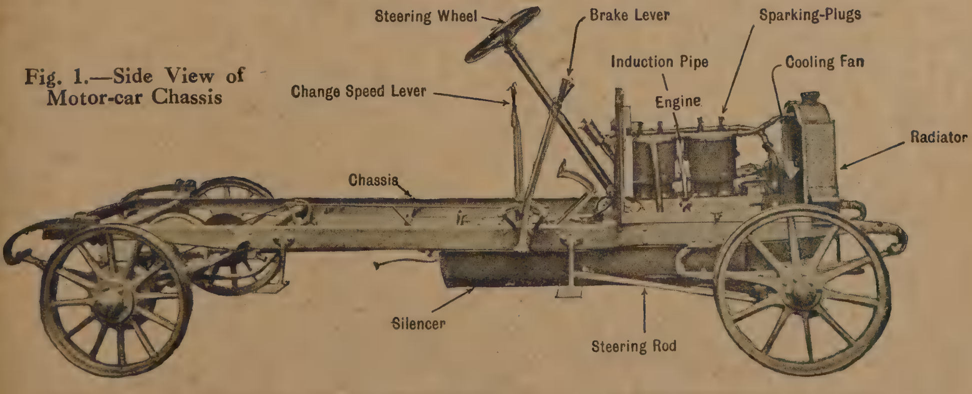


Fig. 1.—Side View of Motor-car Chassis

THE PRELIMINARY EXAMINATION

Engine.—To begin with, make a careful examination by eye alone, beginning with the engine. First inspect the cylinders for any cracks, especially at the corners of the flanges by which the cylinders are bolted to the crank case. The water jackets, too, may be inspected for signs of water leaks. Cracked water jackets are more frequent than is generally supposed, because the expansion of the metal under heat often temporarily stops the leaks as the engine warms up to its work. Leakages on the inside of the jacket, of course, cannot be discovered at this stage.

The arms or brackets supporting the engine and gear box on the frame, also the bolts that hold them in position, should be carefully inspected, especially if a car has had much work on rough roads, or has been in a collision. If the reader is practised in telling by the sound whether metal is cracked or not, a few taps with a light hammer may prove instructive, but care should be exercised in this business, for be it remembered that the metal is only a casting, and, therefore, brittle under impact.

Bearings.—Throughout the mechanism of the car traces of escaping oil, or their absence, will generally give a very fair indication to the condition of the bearings, but the principal thing to look for is looseness, which may be due to want of adjustment or to wear, or both.

Testing the Engine.—With regard to the engine, a test with the car stationary is of more value than a test on the road, for greater attention can be paid to details, and with a car that is in need of overhaul the pulling powers can be no criterion of its condition. Before actually starting the engine, take hold of the starting handle and give it a smart push down, at the same time listening for noise in the timing gear case; if any noise is heard, particular attention should be paid to the condition of the timing wheels when examination is made later. The same procedure applies to the valves, valve tappets and cam shaft, though in testing these an assistant will be required to crank the engine at a steady speed.

The next matter is to test the compression, and for this all the plugs should be removed with the exception of the one in the cylinder being tested. A little paraffin injected into the cylinders prior to the compression test will assist matters, as there will then be no chance of confusing any gumming of the pistons with compression. If a particular cylinder has very faulty compression, observation should be made with a view to locating the leak, for although it would probably be revealed when the engine is dismantled, there is just the possibility of it being overlooked. It is a good plan to pour a small quantity of thick oil on the top of the piston of the faulty cylinder, for if the compression is improved with this treatment the inference is that the rings are faulty or the cylinder is oval. Also examine the valve stems and tappets, and make sure that the valves are coming right down on to their seats. If the valves appear to close correctly, run a little oil round the valve caps, sparking-plug, compression tap, etc., and watch for any bubbles that might appear. Sometimes it is possible to detect a compression leak by listening.

After the compression test, remove all the plugs and turn the crankshaft very slowly, all the time feeling very carefully for any lumpiness or apparent uneven drag on the steady motion of the shaft. If any is felt the angular position of the crankshaft should be noted, for later this may serve to indicate the cause of the trouble. Such a state of affairs may be a very trivial matter, or, on the other hand, it may be of considerable importance, and the fact that its existence has been discovered naturally directs particular attention to the possible causes. Of course, with the possession of very fine measuring instruments it is quite possible to overhaul an engine without anything in the nature of a preliminary examination.

After the sparking-plugs have been replaced the engine should be started, if it is in a condition that allows of it

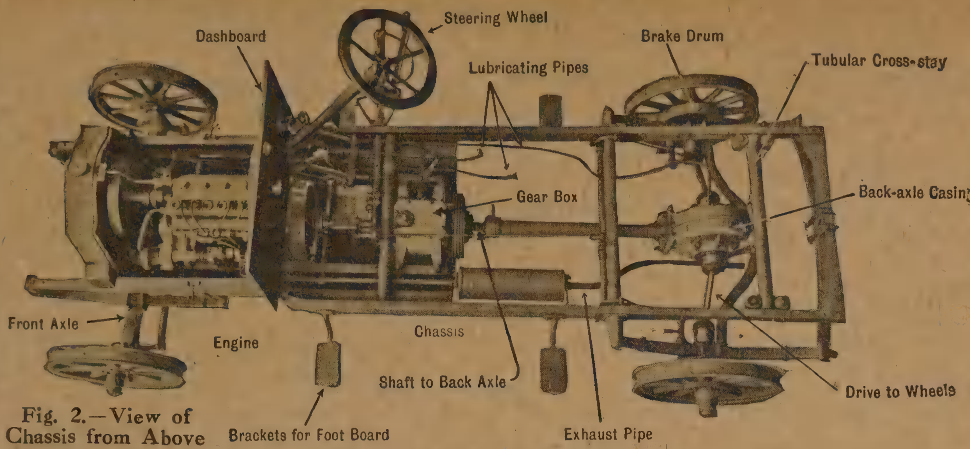


Fig. 2.—View of Chassis from Above

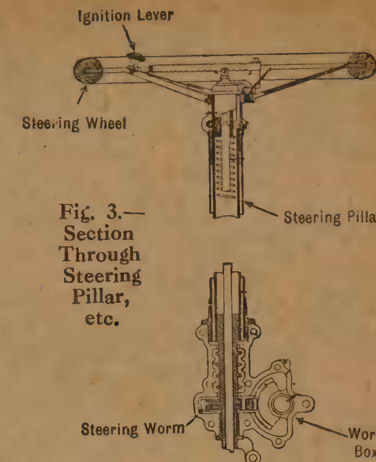


Fig. 3.—Section Through Steering Pillar, etc.

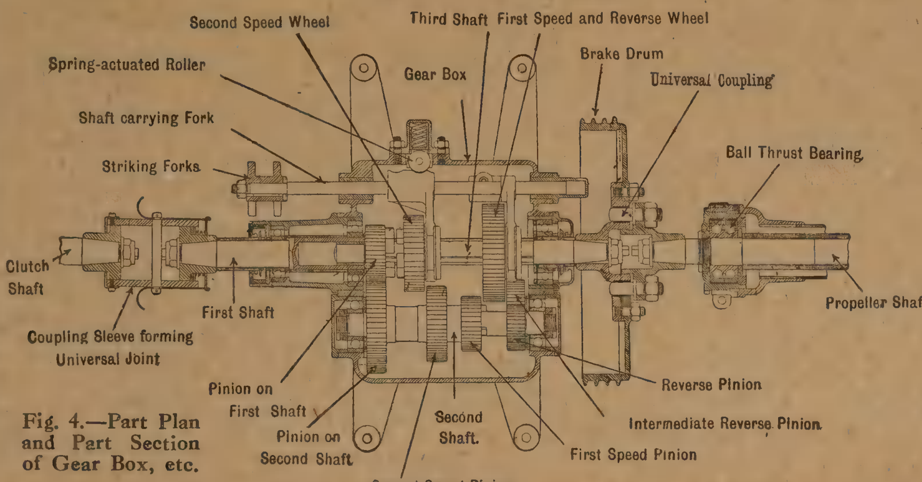


Fig. 4.—Part Plan and Part Section of Gear Box, etc.

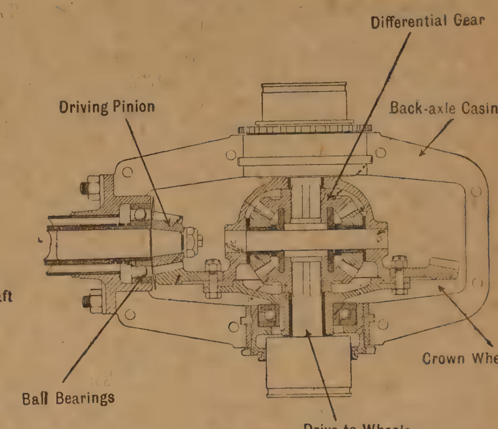


Fig. 5.—Section Through Differential Gear

being run, and careful note should be made of any unusual sounds. The determination of the cause of particular engine noises is only possible, with any degree of exactness, to the person with the trained ear, but their general nature will be outlined in order to serve as a guide. The parts of an engine where wear is usually most evident is in the big ends of the connecting rods, and the resulting noise is in the nature of a dull thud, or in bad cases or at high speeds, a rattle. Worn main bearings will cause a sort of hollow rumbling, probably accentuated at high speeds. Wear at the gudgeon-pin end of the connecting rod, or of the gudgeon pin itself, is evidenced by sharp metallic taps sounding something like an overheated engine, but the noise still persists even when the spark is retarded. Looseness, whether slight or excessive, will generally be revealed in an engine if it is accelerated to a high speed and then the throttle be suddenly closed entirely.

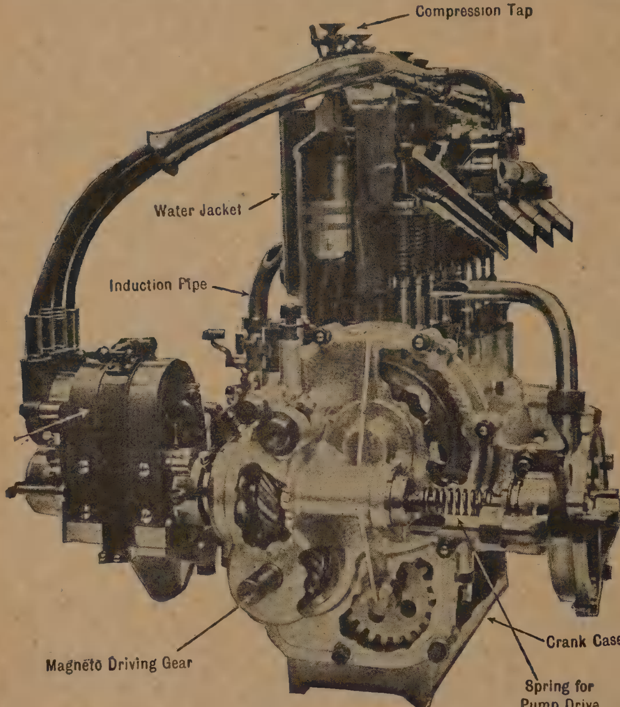


Fig. 6.—Front End of Engine

Even with the engine dismantled the precise cause of a knock may not be very apparent, and it is vitally necessary to exercise a great deal of discernment whilst bearing in mind all the possible sources of the trouble. The knocking caused by excessive carbon deposit may be left out of account, as it is probable that this will only be existent when the engine is hot and under load. Such a knock occurs when the engine gets hot. the sooty deposits causing too early ignition, and though a metallic sound is given out, it is quite distinctive; moreover, it only begins when the engine has got hot. Engines with high compression—in other words, engines in which the compression space is relatively small—are more affected by sooting up than others, for the carbon incrustation naturally reduces the compression space more than proportionately, making the compression higher still, and this, and minute red-hot projections of carbon deposit, acting and reacting on each other, accentuate the evil, which is really caused by automatic ignition of the charge in the cylinder at too early a point. Even apart from this, however, high compression engines overheat more quickly.

Overloading of the engine is another fruitful cause of knocking. It may be that the gear of the car is too high for the load, that the mixture is wrongly adjusted and will not let the engine exert sufficient power, that ignition is taking place too early, or, on a hill, it may be due to the driver not changing down soon enough.

After the engine has been run, make a careful examination of it generally, particularly noting any traces of escaping oil. Probably there will be considerable

wear in the bearing at the flywheel end of the crankshaft, as this has to take most of the strain. It is assumed that the engine will be entirely dismantled, but if not, the condition of the rear bearing may be found by placing a wooden lever under the flywheel and gently attempting to lift it; but care should be taken not to put more strain on the wheel than is just necessary to rather more than take the weight of the wheel. The front bearing can be examined by engaging the starting handle with the crankshaft, and attempting to lift it up by hand. To detect end play in the shaft, get an assistant to engage and disengage the clutch sharply, the thrust of which will move the shaft lengthwise if there is any play in this respect.

Radiator.—Attention should be directed to the water-circulating system, including, of course, the radiator. The correct test for a radiator is to solder a plate over the filler and plug the overflow pipe up, and then to pump air into it and immerse it bodily in a tank of water. With an internal air pressure of about 15 lb. to the square inch, any leak or weakness will quickly reveal itself. The facilities for doing this will probably be out of reach of the average worker, however, and he will of necessity have to be content with a careful examination.

Clutch, etc.—See that the clutch stop or clutch brake brings the driven member of the clutch promptly to a standstill when the clutch pedal is fully depressed; adjustment is usually simple if required.

Look well to the clutch fork. Should it be of the type fitted with rollers, these often have to revolve at extremely high speeds, and as usually they are not sufficiently lubricated, a considerable amount of wear takes place both in the rollers and on the pins, thus causing a very noisy clutch, and an uncomfortable quaking clutch pedal. If, therefore, the rollers or pins are worn they should be renewed, preferably from the makers, as it is necessary for them to be very thoroughly hardened.

Inspect, too, all controls and their connections (not only engine controls, but those of the change-speed and brake mechanism); wear at the joints of these may greatly influence the performance of the car.

Change Gear.—Examine the movement of the gears, with the gear box open for inspection, and if there is the faintest tendency for two gears to engage at once, inspect the selector mechanism immediately, for the cause is almost cer-

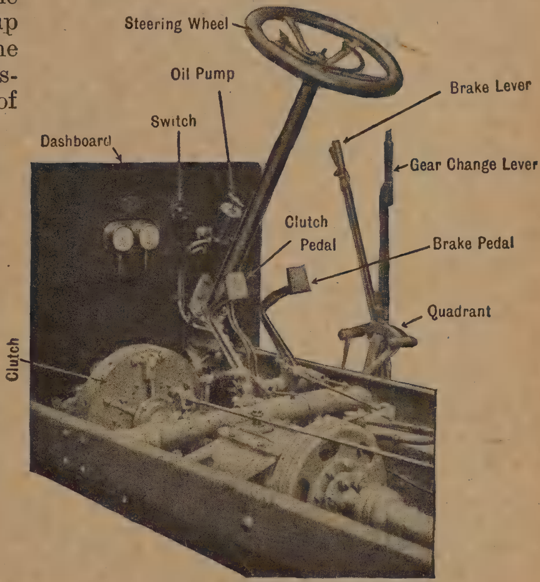


Fig. 7.—View of Dashboard, Clutch, etc.

tainly due to the lever that engages the selector rods having moved laterally. Should the gear lever be difficult to move, the gear box has probably moved relatively to the chassis frame, and the change-speed shaft is binding. This must be seen to in positioning the gear box on the frame.

If with the lever in the natural position the gears are rubbing against each other with a grinding noise, and the lever chatters, probably undue force has been used in changing speed, and the forks have become bent; and, should any of the gears jump out of engagement later on the road, the same fault is probably

at the bottom of the trouble, the striking forks in the latter case having been bent, so that, though the change-speed lever is as far as it will go in the gate, it does not bring the gears into proper engagement. In gears brought into action by dog clutches the trouble may be due to the corners of the dog jaws being worn.

Steering Gear, etc.—The greatest care is necessary in examining the steering gear and front axles, for on them more than on any other parts the safety of life depends. Try each point of the steering gear for shake, gripping the two joints together, and shaking them so that the worker is not misled by the play of other joints entering into the question. If serious wear is evident the joints should be renewed, and these certainly had best be obtained from the makers. Also turn the steering wheel while the car is at rest; the amount by which it will turn easily indicates the amount of play on the reversible gear, whether it be of the nut and screw-thread type or the worm and sector type. Some of the former kind are made with two nuts, the distance between which can be adjusted to take up wear, while in some worm and sector gears the sector—to use an Irishism—takes the form of a complete circle or worm wheel, which at each adjustment can be turned round a quarter turn to bring fresh teeth into engagement with the worm.

Road Wheels.—If the road wheels are out of alignment the fact will show itself by the wear of the tyres, although wear here may be due to the circle of the wheel being out of truth in itself. First jack up the axle and shake the wheels, both crossways to discover radial wear and longitudinally for end play. If the latter, the trouble may be cured by inserting washers to take up the play, but if due to wear of the ball races, these will have to be renewed if the looseness is serious; for, remember, a renewal in time may save a lot more than its cost in the long run.

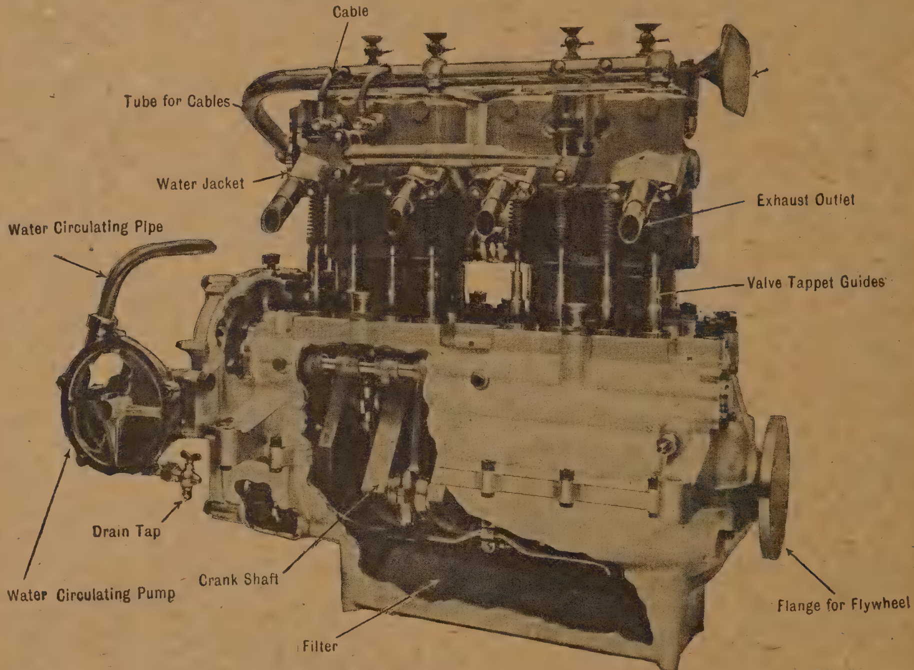


Fig. 8.—Valve Side of Petrol Engine

If there is no material play in the road wheels, test with a lath to see that the wheel rims (not the tyres) are the same distance apart at the rearmost point of their circle as at the foremost point, marking off with the greatest possible accuracy the measurements in each case.

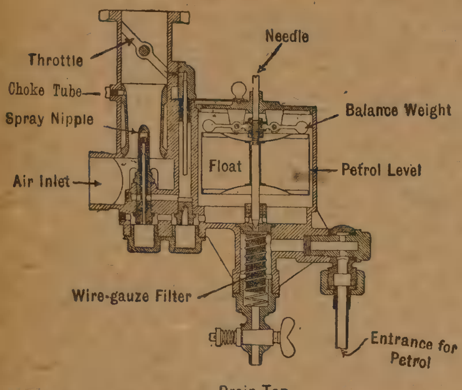


Fig. 9.—Section Through Carburettor

In Fig. 10 A B and C D represent the equal measurements when two wheels are in alignment, while the measurements A E and C F represent, in dotted lines, an exaggerated case of one wheel out of alignment.

The parallelism of the one axle to the other must also be tested by checking with a lath the distance from centre to centre of hub cap on each side. This point is explained by showing the effect with the centre line of the back axle slewed round in Fig. 10 by way of illustration. Check both axles, too, to see that they stand square across the frame. This can be done by availing ourselves of the central line set up when correctness of the alignment of the transmission is being tested, when a square can be laid true with this line, and from it plumb lines dropped to test the position of the axles. If the axle is not true, discover the cause. It may be due merely to the position of the spring or spring shackles, or to wear on the latter; it may be that one of the springs has got a permanent set at one part; it may be due to a heavier load on the one side of the chassis frame than on the other, or in some cases to the seating of the spring having shifted at the axle. If it is caused by a permanent local set in one of the springs, it had better be seen to by an experienced spring smith. Finally, should it be the back axle that is out of alignment, the fault may be due to unequal adjustment of the radius rods on each side. Therefore, measure them up very carefully, and adjust equally if necessary.

To see that the wheels are laterally true in themselves, spin them round while the axle is jacked up. If necessary, a piece of chalk can be held stationary to mark the parts most out of truth, as in centring work on a lathe. It is unlikely that the wheel will be out of truth circumferentially.

If the wheels are of wood, see that all the spokes and felloes are tight, and that the joints of the latter also fit closely. If wire wheels, each spoke should be tested for tension by shaking it, and if necessary it should be tightened. This is a tricky business, however, and unless the reader has had experience, he will be wise to leave it to a professional.

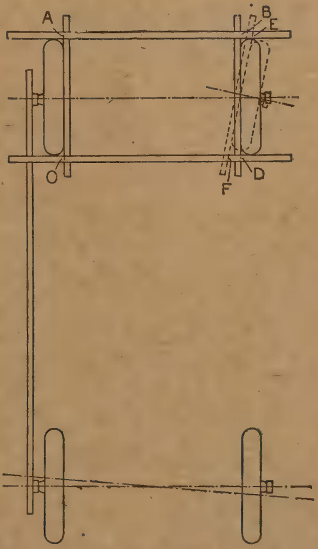


Fig. 10.—Testing Wheel and Axle Alignment

Frame Springs, etc.—Now stand to the side of the car, some 12 ft. or 15 ft. away, and notice very carefully if there is any sign of the frame longitudinals sagging or bending, especially where the frame is inswept to allow clearance for the lock of the front wheels, as this trouble will probably occur here if anywhere. Any suspicion of sag will be strengthened should the doors of the body jam or the joints of the body-work open out. Examine the insweep of the frame also for any cracks.

The frame itself may be true enough, and yet the one side may drop lower than the other. This may be due to the springs on one side having become disproportionately weak. On the back axle the spring on one side is usually made stronger than that on the other, in order to allow for the camber of the road, but still the spring curvature should be the same. Examine, too, where the front cross member is joined to the chassis longitudinals, as fracture sometimes develops here. The spring hangers securing the springs to the chassis also require special inspection.

Carburettor. — Sometimes a carburettor drips continuously. In a properly tuned carburettor the height of the petrol in the float chamber should be exactly the same as, or the slightest bit lower than, the top of the jet, and continual leakage from the carburettor generally indicates that the point of the needle valve is worn, so that it does not cut off the flow of petrol until the level is above that of the jet.

With regard to the carburettor, once the correct level in the float chamber (to the height of the jet) has been ensured, the tuning is largely a matter of adjusting the air supply relatively to the fuel at different speeds of the engine. This, of course, can only be done by running the engine with the controls disconnected, and trying various settings for the carburettor.

For further information on carburettor adjustment, see p. 276 of Vol. I.

"*Popping.*"—If "popping" (the word indicates what is meant) occurs at the carburettor, it is probable that the mixture is too weak, and this may be due to maladjustment of the carburettor, a leaky joint in the inlet pipe connections admitting air, or, what is more rarely realised, a worn throttle spindle or inlet valve spindle or guide allowing air past it. In engines with automatically actuated inlet valves, "popping" may also be due to the inlet valve spring being too weak. An over-rich mixture will tend to choke the engine when the throttle is opened.

If the engine tends to overheat it is also quite possibly due to too rich a mixture, which will probably show itself in the form of black smoke and a strong smell at the exhaust.

"*Hunting.*"—When the engine "hunts"—that is, intermittently and alternately increases and reduces speed—the cause is usually due to too rich a mixture.

Silencer at Fault.—If the engine has not been giving off its full power, note whether the noise from the silencer is more continuous—percolating out from the silencer, so to speak—than with the average engine. If so, and on holding the hand near the outlet the gases seem decidedly hot, it is quite possible that the silencer has become partly choked. Should the exhaust be unduly noisy, look to all joints of the piping and silencer. If these are sound, the noise may be due to baffle plates having come loose inside the silencer.

Undue Heating of Circulation Water.—Undue heating and steaming of the circulation water may also result from defects in the engine, from a choked up silencer, or from trouble in the circulation system itself. In the former case, deposit in the cylinders, incorrect mixture, badly timed valves, or defective ignition are the most likely causes, while in the latter case the trouble may be due to obstruction in the system, possibly caused by some foreign matter, or by lime deposited in the jackets and pipes. When rubber connections are used, look to them; they sometimes contract internally, and so restrict the circulation. When scale has formed in

the system, traces of this scale will probably be found on draining all the water out.

When the water is circulated by pump, the cause may lie in failure of the pump to function properly. In such cases, therefore, notice the force with which the water enters the radiator. Again, the trouble may be due to the fan belt slipping, as it often does when water or oil gets on to it.

Lubrication.—If forced lubrication is led to the various engine parts through outside pipes, disconnect each in turn to see whether, when the oil pump is being driven, the proper supply is passing through each pipe.

Testing on the Road.—Finally, test the car on the road. If possible, run her downhill over lumpy ground with the engine shut off. Any squeak will indicate that oil is wanted between the plates of the springs, or on the spring shackles, but the noise of the unoiled spring plates rubbing together is quite distinctive. Try the car downhill, in her different gears, too, the various noises from which will indicate their condition; also take the opportunity to test the brakes. Then start the engine, try the clutch up a good stiff hill to see how the adjustment is, and also note what sort of power the engine is giving off under load, and whether it is unduly noisy. If so, try to locate the noise. Also note whether the firing is regular.

When a new clutch leather is fitted a certain amount is allowed for wear. Consequently, when new the extreme outer end of the cone projects beyond the female member. Pressure and friction combine to render the working diameter smaller, and a ridge forms on the leather all round the outer end of the clutch, and eventually leads to unsatisfactory engagement. Such a ridge should be shaved off with a sharp knife, so that the whole leather surface is flush.

If any gear wheel teeth are broken off a hammering sound will be heard. Worn gear box bearings lead to a hollow sound which becomes accentuated as the resistance of the drive is increased. Owing to defective lubrication arrangements, the universal joint is often one of the first parts to wear, and if it is badly enough worn to make a clanking noise with the car running, its pins and bushes should be renewed. The same applies to torque and radius rods, while springs interposed between the former and the bracket on the chassis must be renewed if broken. Such broken springs make the axle kick when the clutch is constantly applied.

Ignition.—Ignition is tested in the following way: Take out all sparking-plugs, connect them up again with their cables, and lay them down with the metal part of their bodies in contact with the metal of the cylinder or other metal part of the frame—metal to metal, no intervening paint. Be careful, however, that the body of the plug is the only part that touches the metal; both the terminals at one end and the electrodes at the other end must be far enough away to prevent any spark jumping across. Now, with the switch on, have the crank handle turned round as rapidly as possible, and watch the plugs. A spark—and a good healthy one—should pass between the points of each plug in due turn. If only one or two of the plugs are faulty, thay can be changed over with the other to discover whether the trouble lies in the plugs themselves or whether in the magneto system. Most probably the contact maker points will prove to be occasioning the defect if all plugs alike are unsatisfactory on any one cable, while, if the fault seems to lie in the plugs, it may be due to the points being too far apart, or dirty, or to a broken mica or porcelain.

Magneto adjustment is dealt with on pp. 267 to 278 of Vol. II.

Valve Timing.—It is just as well to test the timing of the valves also, but, though the principle is the same in all cases, each design of engine has its own separate setting, and it is impossible to lay down any hard and fast rules on this matter. For a racing car the setting is different from one for touring, but in general Fig. 11 shows the points of the crank circle at which the valves begin to

open and finish closing. First see that the valves are getting a full and proper lift. Then take a piece of wire and straighten it out—a cycle spoke will do very well—and pass this through the compression cock or other suitable hole in the cylinder to be tested for timing. Now crank the engine round until the piston is absolutely on top of its stroke; make a mark on the gauge wire at the exact point where it begins to project above the cylinder cock. Similarly mark the wire for the lowest point of the piston in both cases, taking care that the wire stands as plumb as possible each time. Now get someone to crank the engine

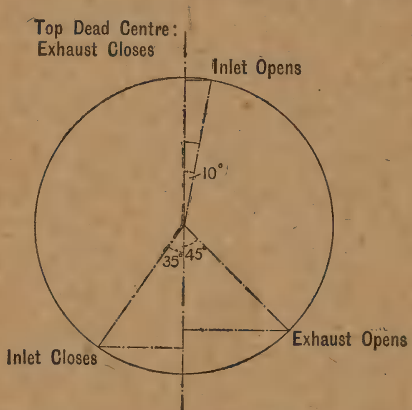


Fig. 11.—Diagram for Setting Valves of Petrol Engine

round, and, watching the valve tappets very carefully, as soon as the inlet shows the faintest sign of beginning to lift, stop the cranking. Then make sure that the wire is plumb, and mark it. This mark will probably come very near to the piston-top position mark, if not right on to it. Assuming that the reader knows the engine stroke, he can, with a pair of compasses set to a radius of half the stroke, draw out the circular travel of the crank pin, and from lines run at right angles to a diameter as in Fig. 11, he can ascertain approximately the angular position of the crank at the moment of valve opening. Similarly, the closing position of the inlet valves and both opening and closing of the exhaust valves may be ascertained, and if they are far out from the diagram it is extremely probable that the valves of the engine are not set to the best advantage.

The Shafts.—As far as possible test the rotation of all shafts to see whether they are running freely. Until the car is dismantled, however, it is not generally possible to do this, as connections with other parts prevent it, but as soon as any shaft is uncoupled and free, turn it round to see how it is running—whether too tight or too loose.

A COMPLETE OVERHAUL

The foregoing hints will guide the car owner as to what has to be done. The doing of it will now be considered. Let it be assumed that a complete overhaul is required. First run all petrol, water, and oil out of the tanks; then disconnect the petrol, oil, and water pipes from the engine, and move them out of the way.

But, before going further, a word of warning must be given. There are so many parts that, unless system is used, they are bound to get mixed, and the amateur will have trouble in putting them together again. Therefore, all bolts, as far as possible, should be kept during the overhaul in the holes to which they belong, and the nuts on the bolts or studs to which they belong, and the same principle should be applied as far as possible to all other parts.

Roughly, the engine overhaul may be divided into two classes: the first is that which consists of removing the cylinders, decarbonising pistons and cylinders, grinding the valves, etc., fitting new rings if required, and generally adjusting and tuning the engine, magneto and carburettor up—in fact, doing everything that may be necessary and that can be done whilst the crank case is still in the frame. It is also possible to extend the work even to taking up the big ends and fitting new gudgeon-pin bushes, although this, particularly the former item, is not to be recommended, as the conditions render it impossible to carry out the work efficiently; and as much of the work has to be done underneath the

engine with the sump removed, the task is not an enviable one. In the second class of overhaul, the engine is entirely removed from the frame either after or before the cylinders are removed, and taken entirely to pieces on the bench.

The things that matter and which should decide how far the overhaul should proceed are the condition of the big ends of the connecting rods, the main bearings, and the crankshaft. If matters are all right in the above respects, in all probability there will be no need to take the crankcase out of the frame.

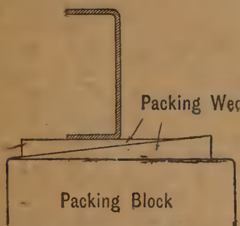


Fig. 12.—Adjusting Level of Frame by Wedge Packing

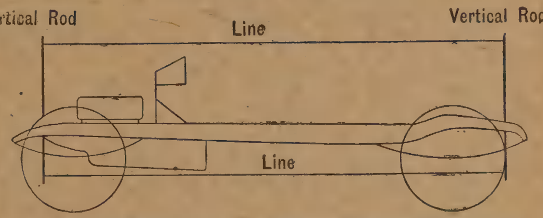


Fig. 13.—Lining Up to Check Chassis Alignment

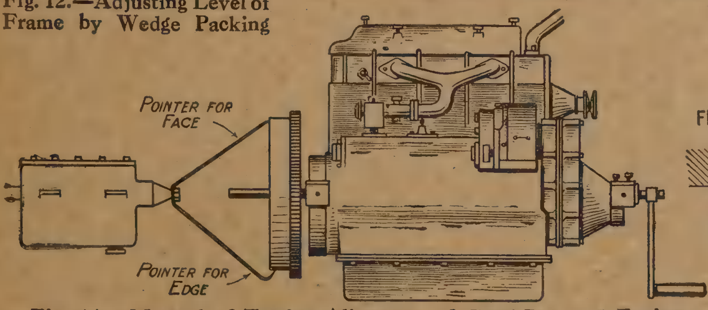


Fig. 14.—Method of Testing Alignment of Gear Box and Engine

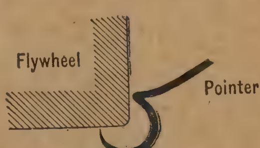


Fig. 15.—Pointer for Alignment Testing

The first step will be to uncouple the shaft between clutch and gear box. Usually this is made with universal joints to allow for the whip of the frame, and consequently it is not a difficult matter.

Testing for Alignment.—Before dismantling further, however, it is advisable to test for alignment. After removing the body, which is secured by bolts to the chassis, first ensure that the frame is jacked up so as to lie dead level and be unaffected by springs, wheels, and tyres. This can, of course, be done with a spirit level, and wooden wedges between the supports and the frame, as indicated in Fig. 12.

There is now a base line from which to work. Mark the exact centre of back and front cross members, and at each of these points erect a rod in an absolutely plumb vertical position (see Fig. 13), so that the rod extends above and below the frame, and clears the dash above and everything beneath. Lines should be tightly stretched between the two top and two bottom points of these rods, and a plumb line, just touching these two, will then assuredly lie in the central plane of the chassis, and should fall across the centres of engine, clutch, and gear box shafts.

Having removed the shaft between engine and gear box, see whether the engine shaft is in perfect alignment. It has been already said that the bearings do not usually wear equally, and that the flywheel generally wears more rapidly than the others. This has the effect of dropping the flywheel down on the cross; hence the engine shaft is thrown out of alignment with that of the gear box. To ascertain whether this is the case, fit to the projecting front end of the gear box

shaft two pointers (see Fig. 14), which should be shaped so as to test the truth of both the circumference and face of the flywheel (see Fig. 15). If the face of the wheel is nearer to the pointers at the top of its circle than at the bottom, it is probably due to the flywheel bearing being disproportionately worn. Make a note of it. When the pointers are fitted, the opportunity may be taken to ascertain whether the gear box and engine are in proper alignment with each other, by testing with the pointers all round the flywheel (the method is self-evident from Fig. 15). If not in alignment, and the chassis frame is not apparently distorted, the matter will have to be remedied in

Fig. 16.—Method of Removing Piston Rings

the reassembling, of which more later. In the meantime note the direction of malalignment and its extent.

Dismantling the Engine.—In commencing the actual overhaul, the first task is to drain the oil out of the sump by means of the plug or cock that is provided for this purpose, and also the water out of the radiator. The radiator connections can then be loosened, and if it is intended to remove the engine from the frame, the radiator can be taken off entirely.

The next items to be removed are the oil pipes to the dash, magneto wiring, and any other incidentals that will prevent the cylinders being lifted. The exhaust-pipe connection to the exhaust manifold should be freed, and then the induction and exhaust manifolds removed. After the cylinder holding-down nuts have been taken off, the cylinders should be ready for lifting; but before this is attempted complete assurance should be made that everything is quite free, for it is most annoying to get the cylinders partly off, with perhaps one or two of the rings out, and then find that something is preventing their complete removal. The same remarks apply to any other obstructions, such as a radiator tie rod, etc.

If the cylinder block is a single casting, or the cylinders are in pairs, assistance will be required to steady the pistons as they leave the cylinders, otherwise there is a danger of them coming out of the cylinders suddenly and falling over and cracking their skirts on the connecting rods.

The task of removing monobloc cylinders of any size is not an easy one, for it is necessary to keep them almost perfectly parallel with the crankcase during the whole of the lift. The simplest way is to stand over them with one foot at each side on the frame, and grasp them at such a position as may be judged to be about the point of balance and lift as nearly vertical as possible, but at the same time imparting a horizontal to-and-fro twisting motion to them, an assistant meanwhile standing by to steady the pistons as they leave the cylinders.

The removal of the cylinders completes the first stage of the dismantling of the engine, and it now becomes necessary definitely to decide, after a general examination, as to whether it shall be entirely removed from the frame. The examination should be systematic, and include all parts that are likely to have suffered by wear. The first items to examine are the pistons, rings, and the condition of small-end bearings and gudgeon pins. Each connecting rod in turn should be grasped firmly with one hand and the piston with the other, and a test made for shake.

It may be stated that the detection of a slight amount of play in a bearing that has oil in it is difficult, and if any doubt exists, it is far better to dismantle the part and try the parts when clean and dry. A side rock in a bearing is a truer

indication of wear than what can usually be gathered from trying for distinct up-and-down movement, and if any side rock is detected the piston and pin had better be removed.

The removal of a piston at this stage is often a difficult and tiresome matter, and if the dismantling is to be proceeded with it is better to leave it until later. The next test should be that of the big ends, and for this the same remarks apply as above, their state being chiefly gauged by the amount of side rock existing.

Assuming that the general condition of the engine does not warrant further dismantling it, the pistons should be scraped free from carbon both inside and outside, the piston rings being removed for this purpose. Fig. 16 shows the method of removing piston rings safely. Three narrow strips of thin sheet steel are slipped behind the ring, and carefully worked round into such a position that the ring can be easily slipped off. It must be remembered that the rings are of cast-iron and that their limit of flexibility is very slight. Each ring when it is taken off should be placed in some position that will enable the worker to restore them to the same groove of the piston from which they were removed. An easy way of doing this is to drive a nail in the wall for each cylinder, with the number of the cylinder marked underneath, and place the rings on the nails in their correct order. When the cylinders are cleaned, each ring should be tested for fit in its own cylinder. The testing of the pistons whilst still in place is not possible, but in this matter the original running test of the engine will have given some indication, and if there is any doubt at all about them they should be removed for testing.

It is necessary to mention at this point that from this stage every part should be marked as it is removed from the engine. It is quite probable that many of the parts will be found to be marked already, especially if the engine has been dismantled previously, and therefore search should be made for any marks in order to avoid a duplication which might lead to confusion. A centre punch is usually used to do the marking, and the number of dots on the top of a piston indicates its cylinder number. In the case of valves which are placed at both sides of the cylinders, the system usually employed is to commence with number one at the left-hand side when facing the front of the engine, and proceed with the number up that side and down the other consecutively. Not only should the order be indicated by the marking, but also the position; thus the marks should be so disposed that it will be possible to tell which side of a piston was facing the front of the engine, and the same with the connecting rods. Too much stress cannot be laid on the importance of this marking that will assist in the replacement in the same order and relative positions as originally occupied. In most cases it is advisable even to replace all the nuts on their original bolts or studs, and in the case of the big-end bolts and main-bearing studs it is essential to do so.

Lifting Out the Engine.—Before the engine can be lifted out of the frame it will be necessary to undo the holding-down bolts, but before these latter are undone a line should be scribed on the frame round each engine bearer in order that the engine may be returned to exactly the same position. When it comes to reassembling it should not be taken for granted that this position is absolutely correct, as before mentioned, but the lines will act as a check in the lining up of the engine and gear box.

With assistance, a fairly small engine minus the cylinders can be lifted out of the frame without any mechanical appliances in the nature of tackle; but if of any size a set of pulley blocks will be required, a cradle rope being passed twice under the engine, and, when the approximate point of balance has been found, also around the hook, so that the engine does not tilt during the lifting. Most of the work of overhaul will be done with the engine upside down, and so supported that the flywheel can be turned. If a proper trestle is not available, it is

not a difficult matter to arrange a substitute; two benches or tables placed about 18 in. apart will answer. Engine stands are obtainable in which the engine can be turned completely over, so that when the work on the underneath part is completed the engine can be reversed, and the fitting of the cylinders proceeded with.

Continuing the Dismantling. — The engine on the stand, the sump can be removed, and next the clutch and flywheel. The latter is usually attached to the engine shaft by six bolts passing through a flange on the crankshaft, and before the wheel is removed, it and the flange should be marked with corresponding marks, so that it can be returned to its original position. There should be no

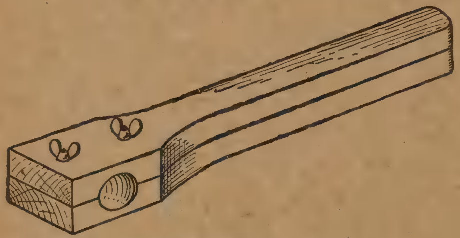


Fig. 17.—Wooden Lap for Smoothing Crankshaft

difficulty in getting the flywheel off, but if there is, a few taps with a baulk of timber will most likely free it. If more severe measures are necessary, a chain passed twice round the back of the wheel and over a jack held on the end of the shaft provides a good improvised apparatus for the work. The big-end caps can next be removed, care being taken that each is marked so that it can be replaced in the same position. With the cap removed, the piston and connecting rod can be withdrawn from the under side, when the caps should be immediately replaced and the nuts returned to their respective bolts.

With the connecting rods off there will now only remain the crankshaft to take out, with possibly the cam shaft if this shows signs of wear or looseness; but before this is done a very careful examination of the timing wheels should be made, note being taken of the depth of mesh of the wheel on the end of the crankshaft with the larger wheels. The reason for this is that should there be any considerable wear in the front bearing, the taking up of this would cause the wheels to be too deeply meshed unless due precautions were taken, and the result would be that all the main bearings would have to be done again, which a little foresight would have avoided. Observance should also be made whether the timing wheels are marked so that they can be replaced in their relative positions.

Generally, the camshaft does not show much signs of wear, and in all probability it will not be necessary to remove it; but each cam should be examined, and also the state of the camshaft bearings. At the same time the tappets and their guides should be looked at, particular attention being paid to the tappet rollers, or if the tappets are not provided with rollers, the shoes or rockers, as the case may be.

All the parts of the engine should now receive a thorough washing in paraffin. The washing should include the cleaning out of all oilways, and assurance made that all are quite clear. The practice of cleaning out oilways with small pieces of waste and wire is not to be advocated; the correct method is to have a small brass syringe with a fine nozzle, and use this for the injection of paraffin.

The Oiling System.—It is useful at this juncture to make a study of the oiling system, for it is quite an easy matter in the re-erection of the engine to miss some vital point, which may easily cause the bearings to be ruined. In this connection the actual bearings should be studied, and a note made of what oil channels are cut in them, for if the bearings have to be re-metalled these oil channels will have to be duplicated; this applies both to the big-end and main bearings. The main bearings should receive the first attention in the way of overhaul, but previous to doing these a determination of the condition of the crankshaft will be of great service,

for it is impossible to get a crankshaft that is bent or that has oval journals to bed properly. Such a state of affairs would become apparent as the work of bedding the crankshaft into the bearings proceeded, but knowledge of it beforehand would save a good deal of trouble.

Truing Crankpins and Journals.—Regarding the truing of the crankpins, supposing these to be oval, this work can be carried out in three ways—by hand alone, by hand and lapping in a lathe, or by grinding in a special grinding machine. The last-named method, of course, produces the best results, but with care the hand method can be made to serve quite satisfactorily, leaving little to be desired in the result. Lapping a shaft in the lathe is no remedy for oval pins or journals, though it is useful for taking out any roughness or grooving. A lap may be easily made by boring out a piece of wood, as shown by Fig. 17, to a slightly larger diameter than that of the shaft, and lining it with sheet lead. Two bolts with nuts are provided in order to clamp it on to the shaft after emery or carborundum powder and oil have been smeared on the lead linings.

The truing of a shaft by hand requires the very greatest care accompanied with sound reasoning. Although the shaft is spoken of as being oval, the shape in all probability will be that of a circle with a portion of the circumference removed, a fact that should be borne in mind when the work is in progress. The tools required are a dead-smooth file and a micrometer, or if the latter is not available, a pair of callipers may be made to serve if very carefully used.

It must be remembered that there is very little metal requiring to be taken off, and measurement should be frequently made. When a stage is reached that the pin or journal is approximately correct, it should then be finished with a strip of emery-cloth smeared with oil, but even during the finishing process recourse should be had to the micrometer.

Bedding the Crankshaft.—Assuming that the crankshaft has been brought to a satisfactory state, the next matter is to bed it into the main bearings, after which the bearing caps are to be fitted, and then the connecting rod big-ends fitted to the shaft. This entails the use of a scraper (Fig. 18), which can be bought, or one may be made by the worker from a half-round file. Scraping a set of bearings may easily take twenty-four working hours, or in the case of a set of re-metalled bearings, double this time. The constant repetition of the same work would appear to make the scraping of bearings a very tedious matter, but without a doubt in practice it is one of the most interesting details of engine overhaul, and the attempt to attain perfection becomes engrossing.

A preliminary to the work should be the thorough cleaning of the shaft, and

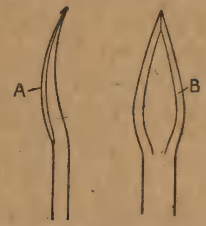


Fig. 18.—Scraper for Bearings

then the journals are lightly smeared with a mixture of powdered prussian blue and oil or lampblack and oil. Oil colour as used by artists makes an excellent marking. Only the merest trace of the mixture should be put on, it being rubbed to an even surface with the finger. The shaft is now laid in the bearings and given two or three turns, a certain amount of pressure being applied at the same time, after which it is lifted out and placed on one side.

As the shaft may have to be lifted out anything from fifty to a hundred times, some convenient place to put it should be arranged. When the bearings are examined it will be found that they are more or less marked. It may be that the marking is fairly even, in which case very little work on them will be necessary, or they may occur when it is necessary to remove quite an appreciable depth, which might have the effect of

bringing the wheels too deeply into mesh. The packing of bearings—that is, the placing of thin metal foil behind them—is not advocated, though, short of re-metalling it is sometimes necessary. Such a case might occur with a very low centre bearing, which would necessitate lowering the two outer ones; usually, however, the use of packing can and should be avoided.

Scraping should be commenced on the bearing that shows itself to be the highest, though as the work proceeds it is generally necessary to work one with the other, and all the time the influence that one will have on another should be kept in mind. It is of importance to keep the tool sharp, and a few light rubs on the oilstone at frequent intervals will be necessary. No attempt should be made to take off thick shavings of metal, for this will result in a very uneven surface that will entail a lot of work getting right again. Each cut should overlap the previous one, and should be made with a swift circular sweep, the scraper in this manner being caused to travel over the whole of the marked part of the bearing. The finishing cuts should consist of a series of very small circular sweeps that remove the minimum of metal, the action of the tool being then more that of a burnisher.

The scraping-in of a set of bearings that have been re-metalled is upon the same lines as already outlined, but greater care is necessary at the commencement in order correctly to locate the shaft and at the same time ensure that all bearings are about level. A steel straightedge of such a length that it will pass over all the bearings at once is of great assistance in the preliminary levelling up of a set of new bearings.

Fitting Main Bearing Caps.—With the shaft bedded in to satisfaction, the caps can next be fitted. In some engines these are provided with shims or metal-foil packing pieces placed between the holding-down studs. The purpose of these shims is obvious, but it will also be evident that letting a worn bearing down, although it may provide a bearing surface, does not make a good fit, and that to do this the surface of the bearing must be cut away and let down still farther. If shims are not provided, the cap has to be slightly filed, but in each case the tightness of the bearing must be determined by the fit of the shaft, and not by the amount of pressure that is brought to bear by means of the nuts. In the operation of fitting the caps the shaft is allowed to remain in the crankcase, and therefore the labour of lifting it in and out for the purpose of trial and correction is avoided; but against this is offset the screwing-down of the caps each time the bearing is scraped. A box spanner is the best type to use for this purpose, as with this type there is less chance of damaging the nuts, and also the worker can be more certain that the nuts are tightened up to the same degree of tightness each time. The nuts for the cap studs will usually be found to be numbered, but if not, they should be marked in order that they may always be replaced on their respective studs. It is also sometimes found that the nuts are marked in such a way as to indicate the point to which they should be tightened up; but the use of such a system is not advocated, as it implies that the fit of the bearing is to a certain extent dependent on the degree of tightness of the nuts rather than the actual fit of the shaft in the bearings.

The bearing should be tested by lightly marking the shaft and then screwing the cap down and giving the shaft a few turns, when the cap is unscrewed and the bearing examined. A piece of iron about 15 in. long bolted to the flywheel flange will be found to be a great convenience for turning the shaft when a trial is being made. Not only has a good surface to be produced, but also the bearing must be of the correct degree of tightness. Only experience will teach exactly how tight a bearing should be, but a rough indication may be gathered by placing the hands on the webs of the shaft and attempting to turn it. With a medium-size engine it should be possible to do this easily, but with a large engine with large diameter journals it should be a matter of some difficulty. Even with the smallest

engines there should be no inclination of the shaft to spin or continue its movement after the pressure is removed.

The cumulative effect of the tightness of all the bearings must also be taken into account, which, of course, will depend on their number, and in this connection it is essential to test each individual bearing with the others quite free, assuming that they have been fitted. These remarks, of course, apply only to white-metal bearings; phosphor-bronze bearings, which are very rarely fitted now, require to be much more free—in fact, as free as possible without perceptible shake.

When each of the main bearings is deemed to be correct the shaft should be cleaned, laid in the bearings, and all the caps fitted for the purpose of trying the degree of tightness of the shaft. By taking hold of the crankshaft webs it should now be a fairly easy matter to keep the shaft revolving, though the starting of the motion should present a little difficulty with the small amount of leverage obtainable with the hands upon the webs. A good bearing always presents what may be likened to a sort of stickiness, that is, it seems to resist the commencement of any motion, yet is comparatively free during its continuance. No bearing should be passed as satisfactory that is dependent upon the extent to which the nuts are pulled up for its degree of tightness, for after a little wear the cap of such a bearing will be quite loose and free to shake about. If it is considered that the shaft is too tight it should be taken out and the bearings wiped free from oil and carefully examined, when it will probably be found that there are a few high places, evidenced by their brightness, and whose removal will make all the difference.

Fitting Big Ends.—To fit the big ends the shaft should be supported in the vice as shown by Fig. 19, with a forked piece of wood at the outer end to relieve it of any undue strain. This system of working requires two vices, one to hold the shaft and the other the bearing being scraped; and if two are not available the shaft may be laid on the bench, with one end projecting and held in place with a metal plate and a bolt, the latter passing through the bench top.

Each rod must be fitted to its particular pin and also in its correct position, and care must be taken throughout the processes of scraping and trial that the one position is maintained. The procedure is practically the same as in fitting the main bearings; if shims are provided, slackness is taken up by the removal of one or two, or in default of these by filing the caps. The amount of metal taken off the caps should be very small, as it is obvious that the repetition of this to any extent

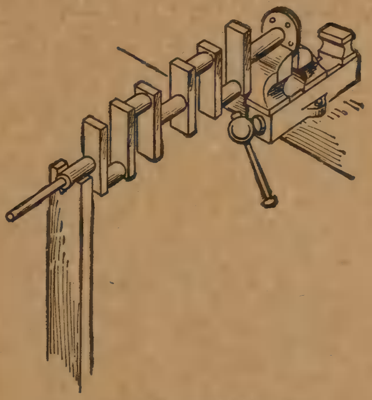


Fig. 19.—Crankshaft in Vice

would soon destroy them; in a case where a bearing cannot be secured with the removal of a comparatively small amount of metal, the bearing should be re-metalled.

When an even marking is obtained the bearing should be lubricated and tested. Practically the same remarks apply as with the main bearings, but in this case careful observation should be made for the detection of any side rock. The requisite degree of tightness may be tested for by swinging the rod round the shaft, when it should make one and a half to two revolutions and then stop dead in any position without any suggestion of return or swinging movement. Also it should be possible to feel a preliminary resistance to motion, which, as in the case of the main bearings, may be likened to a stickiness.

Fitting Gudgeon Pins.—When each rod has been deemed satisfactory, the gudgeon pins should be tested in the small-end bearings. The necessary conditions are that the pin should be a tight friction-fit in the pistons and an easy sliding-fit in the small-end bushes. It is probable that both the pin and the bush will have worn, and the renewal of both will be essential. The slightest amount of slackness between gudgeon pin and bush will be very noticeable when the engine is running, therefore it is a matter that should receive careful attention. Usually it will be found advisable to obtain both pins and bushes from the makers, though if preferred the pins can be turned up out of mild steel, allowing $\frac{1}{100}$ in. in diameter for expansion under the case-hardening that follows.

Gudgeon-pin Bushes.—It is possible to close a bush in if it is not too badly worn, and so render it suitable for further use. The bush should be removed from its housing, and as it is necessary to avoid damaging it, this should be accomplished by pressing it out in the vice by placing a piece of tube of slightly larger diameter behind it, and a short cylinder of brass in front on which to exert the pressure. The bush when taken out is to be well and evenly tinned all over on the outside, when it is again pressed into its housing, care being taken that any holes drilled for the purpose of lubrication register correctly. Upon trying the pin again it will be found that the bush has closed considerably, and that it may be necessary to reamer it out before the pin will fit. An expanding reamer is the best for this purpose, but if one is not available a makeshift may be improvised by packing an ordinary reamer, or alternatively the bush may be scraped. If it is found that the bush has not closed sufficiently, this may have been due to the sharp edge of the connecting rod where the bush enters having sheared the solder off, and this may be avoided by slightly rounding the edge in order to give the bush a lead.

Commencing Re-erection.—A commencement can now be made with the re-erection of the engine, such matters as valve grinding, etc., being left until later. It will be advisable to give all the oil channels another syringing out with paraffin, and in this connection, as the erection proceeds, a careful check should be kept of the lubricating arrangements, that is, the observance that oil holes register and that no oil channels have been omitted. The main bearings should be lubricated and the shaft laid in place. Observance should now be made to get the timing wheels correctly meshed, and as in some cars these cannot be altered once the shaft is in, there must be no question of error. The timing of the valves has already been explained.

When each bearing cap is placed in position the nuts should be drawn up gradually and in turn, so that the pressure is distributed evenly. After all are assumed to be tight, a few light blows with a hammer on the cap will permit of the nuts being given a little more movement without extra undue strain. Each nut should then be secured with a split pin so fitted that the pin has no shake. This is a matter that should be observed right throughout engine erection, that is, the pins should be of such a tight fit as to preclude their moving about, or they should be bent in such a manner so as to attain the same object, otherwise there is always the possibility of a pin wearing through by constant movement and falling out.

The connecting rods should be fitted next, the same procedure being carried out as with the main bearings.

Frequently it is only possible to fit the flywheel with the sump off, so this should be the next item. In fitting this no effort should be spared in getting the bolts perfectly tight and the nuts carefully pinned. If the flywheel is not marked with numbers that show the position of the crankshaft, it will be as well to mark it now that the wheel is in place, as this will be helpful in timing the ignition. A punch mark on the flywheel with No. 1 crank at the top of the stroke and a corresponding mark on the crank case will be sufficient, as other positions can be determined from these.

A paper washer will be required at the joint of the crankcase and sump, and this may be simply cut by placing a sheet of paper on the edge of the sump and lightly tapping with a hammer, or a marking may be obtained by rubbing the paper with the handle of a tool and the washer cut out with scissors. Gold-size is the best medium to use for sticking the washer down to the crankcase, but before using the size it is better to leave it standing in an open, shallow tray for twenty-four hours in order that it may thicken.

At this stage, with the sump on, the engine should be reversed on its trestles or stand, ready for the fitting of the pistons and cylinders. The pistons in any case will require a careful examination and trial in their respective cylinders, in which they should present a clearance of approximately $\frac{7}{1000}$ in., though this figure will vary somewhat according to the size of the engine. If the pistons are found to be in order they can be fitted, not forgetting to place oil upon the gudgeon pins before these are inserted. The method of securing the gudgeon pins will differ with various engines, but no precautions should be neglected in ensuring that a pin is quite secure. If a set-screw is provided that is prevented from turning by means of a split-pin, this latter should be fitted in such a manner that it cannot shake up and down with the motion of the piston, or it will wear through and fall out, with possibly disastrous results.

Attention can now be turned to the cylinders. Each should be carefully examined inside in order to see if they are scored, particularly along the path of the gudgeon-pin ends. If the cylinders are scored they will have to be ground out —necessitating new pistons—and this will also be the case if they have worn oval to any extent. Most of the wear will have occurred on the walls at each side of the crankshaft—in a direction at right angles to the shaft, in fact. It is possible to have scores filled up by the electrolytic process, but this is specialists' work.

Testing Cylinders.—Cylinder wear may be tested for by placing a pair of callipers inside and very carefully adjusting them so that they will move about $\frac{1}{8}$ in. from side to side. Various parts of the cylinder should be tried, always maintaining the callipers directly across the cylinder bore; if the possible sideway movement is not more than $\frac{3}{16}$ in., the bore will be sufficiently parallel to obviate the need for reboring.

Fitting Piston Rings.—The rings should now be tried in the cylinders and also in the piston grooves, and if the gap of any ring exceeds $\frac{1}{32}$ in., or the ring is loose in the groove to such an extent that a distinct up-and-down motion is possible, a new ring should be fitted.

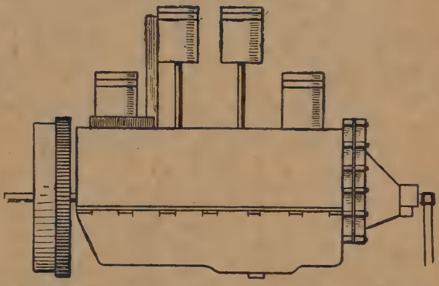


Fig. 20.—Method of Testing Truth of Pistons

If the grooves are worn it will be necessary to obtain a ring rather wider than the standard size, and either have the grooves turned out (this method should be adopted if there is any shoulder present in the groove) or to rub the ring down on a sheet of emery-cloth placed on a flat surface. The fit should be such that the ring can be freely rolled around the groove but yet not have any perceptible up-and down play. In order to obtain the correct gap, the ring can be placed in the vice with the slightest of pressure and one end carefully filed. No difficulty will be experienced in getting the rings on the piston, though it must be borne in mind that they are only cast-iron, and that therefore they should be only expanded to the minimum requisite to get them into place; also no attempt should be made to pass one ring over

another, and in order to avoid this the first ring should be carefully bridged over the intermediate groove.

Valve Grinding.—In default of a special tool for removing the valves, a piece of wood may be placed under the valve cap and the latter screwed lightly down, when the wood will prevent the valve lifting off its seat whilst the spring is compressed and the cotter withdrawn. Valve grinding is a tedious business, and if the valves are badly pitted it is preferable to have them machine ground, both on the score of saving labour and injury to the valve seats; afterwards they can be lightly ground on to their

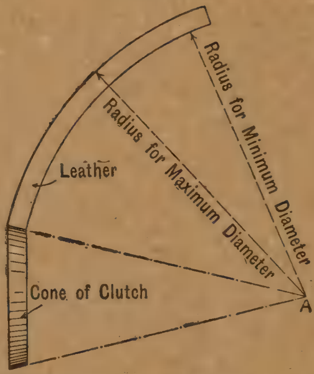


Fig. 21.—Method of Cutting Out Leather for Cone Clutch

seats with powdered emery or carborundum and oil. In grinding valves by hand it will be found that the labour is considerably lightened and much wrist-ache avoided if the screwdriver is properly held. The motion, it should be noted, should be reciprocatory and not circular, otherwise a brace and screwdriver bit could be used, also the valve should be frequently lifted off its seat and its position varied. A light spring placed under the head of the valve will do the lifting if the pressure on the screwdriver is momentarily lessened, and in the aggregate it will be found that this simple device will save a considerable amount of time. After the valve grinding, the cylinders must receive a thorough cleaning, so that no traces of the grinding medium remain, and then the valves should be refitted, each, of course, in its correct place.

Truing Connecting Rods.—Whether the cylinders are put on now or later, when the engine is in the frame, can be best decided by its weight and the means available for lifting it. Certainly it is more accessible on the bench or stand for the final adjustments to be made, but the cylinders add considerably to the total weight; if it can be handled all right it is recommended that the cylinders should be fitted now. Assistance will be needed, and in the case of very heavy blocks some mechanical aid also will be required. Before this work is commenced the pistons must be tested for truth, and this is accomplished as shown in the diagram (Fig. 20). If it is found that the pistons are not perpendicular owing to some slight change having been made in the parallelism of the big-end bearing, the connecting rods must be slightly bent by means of a powerful wrench or twisting bar. It will be found that this operation is by no means difficult, and that only a very slight bend needs to be put on the connecting rod, unless there is some very radical defect in the bearings which should not have been allowed to pass.

Replacing Cylinders, etc.—With a four-cylinder engine the putting on of the cylinders will be facilitated if the two middle pistons are placed at the top dead centre. The cylinder block, after the insides of the cylinders have been smeared with oil, should be held directly above them, when they can be entered into their respective cylinders to a point just above the top rings, and when these latter are pressed up, a little more downward movement and the rings will slip in, and then the next ring can be dealt with in the same way. Once all the rings are in there will be no difficulty, and the same procedure can be adopted with the other pistons. Where there are three rings on a piston the gaps should, of course, be spaced 120° apart, and diametrically opposite in cases where there are only two rings. It is usual to fit a paper washer at the joint between the cylinders and

crank case. In tightening the nuts that hold the cylinders down a little pressure should be applied to each in turn until all are tight.

The fitting of the exhaust and inlet manifolds is a simple matter, copper-asbestos washers being used at the joints of the former. Inlet pipe joints are preferably made with softer material, such as Hallite, but whatever is used care must be taken that there are no chances of an air leak. If there are metal water-pipes bolted on to the cylinders these also can be fitted now, suitable packing material being three- or four-ply canvas, such as is used for tyre repairs.

It is improbable that the magneto will need much attention, but it should be cleaned and oiled, and observance made that the points are separated the correct distance (·4 mm.). If the contact points appear very much pitted, a careful trimming with a very smooth file will improve the action of the machine; the freedom of the rocker on its pivot should also be noted, as the fibre bush has a tendency to swell and cause it to stick.

Timing the Magneto.—It is preferable to re-time the magneto rather than slavishly follow the old setting which may not have been of the best. The first thing to do is to get No. 1 piston at the extreme top of the compression stroke, and this can be attained by the marks previously put on the flywheel or by the insertion of a piece of wire through the compression tap. Note should be made that it is the compression stroke, as of course the piston will be in the same position at the completion of the exhaust stroke. Now fully retard the magneto and turn the shaft round, and note the position of the distributor, which should be on the segment connected to No. 1 cylinder; if not, the magneto shaft must be further revolved until this is arrived at when it is coupled up, with the contact points just about to separate. If the magneto is not provided with advance and retard, the coupling should be made so that the points are just about to separate a little before the piston had reached the top of the compression stroke, the exact position depending on the stroke of the engine, and only determinable by experimenting with the ability of the car to run at low speeds without knocking (see also pp. 267 to 278 of Vol. II.).

Renewing Clutch Leather.—When the clutch is leather-covered, and the leather is burnt or badly worn, it must be renewed. First procure a piece of the best English leather of uniform thickness throughout; then find the angle of the clutch, and, with a tape measure, most accurately measure the outer circumference. Draw out the clutch full size, and from the produced apex A (Fig. 21) of the clutch cone strike out two arcs,

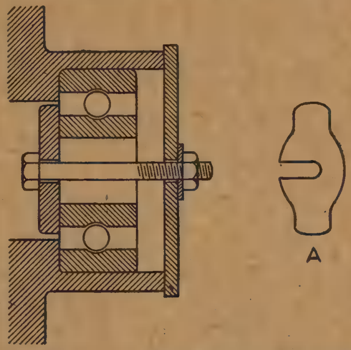


Fig. 22.—Method of Withdrawing Ball Bearings

making the one equal in length to the outer circumference by tape measure, the inner arc equalling the minor circumference of the cone. Soak the leather for some hours in water. Cut and punch out the old copper rivets and remove the old leather. Then rivet one end of the new leather to the cone and stretch it tightly (carpenters' big wooden clamps are useful) to the next rivets, and so work your way, riveting the leather right round.

Swivel Bearings, Wheel Bearings, etc.—The car now should be jacked up and the axles supported so that all the wheels can be taken off. First examine the swivel bearings of the stop pivots on the front axle. This is a most important and vital point, and it will be found good economy to renew bearings if at all worn here. The wheels have already been tested for end and radial play, and if the

renewal of the bearings is doubtful, the worker should be guided by the general appearance of the bearings. If they seem in good condition they might be allowed to run a little longer, but otherwise they should be renewed—and it is as well to err on the safe side when considering the renewal of wheel bearings.

Ball Bearings.—Any ball bearings that are seriously worn and slack should be renewed. In most cases it is cheaper to renew one part in good time to save other parts. In the cases where the inner race is pressed on to the shafts, the bearing can be removed by slipping a tube over the shaft, and with this, pressing or knocking the race from the shaft. Often, however, the outer race is pressed into a seating in the outer casing, and the bearing may then be drawn out by inserting a piece of iron or steel shaped as A (Fig. 22) to take a bolt. A washer is slipped over the bolt end projecting from the casing, and the bearing withdrawn by turning the nut. Care must be taken to ensure that the bearing is held in a true position during removal, and any burrs caused to shaft or casing should be removed.

Tyres.—Examine all the tyres and mark with chalk—or, better still, tyre paint—any parts that require re-vulcanising. Remove the tyres, examining the beading carefully to see that it has not been damaged from rust of the rim. Remove all rust from the rims (paraffin is useful), and, finally, having thoroughly cleaned the surfaces with petrol and made them dry, cover any exposed patches of metal with hard-drying paint, giving the rims the maximum possible time in which to dry. This job had better be done early in the proceedings for this reason. Where detachable rims are used, see that all joints are free from rust. If not, clean with paraffin, and rub with an oily rag.

Gear Renewal, etc.—The renewal of gears is a difficult matter to decide, and the noise they make when the car is running, together with the appearance and play between any two in mesh, must be the guide. New gears should certainly be obtained from the makers. When gears are in mesh, and the bearings of the shafts upon which they are mounted are worn, the wear enables the shafts to be forced away from each other to that extent when the gears are at work. The fitting of new bearings prevents the forcing apart of the shafts; therefore, the fitting of new bearings may, for a time at least, result in considerable increase of noise from worn gears.

Oiling Axle Springs.—If the car has been squeaking, particularly over lumpy roads, the plates of the springs need oiling. Implements for forcing the plates apart are sold, but a cold chisel should be quite effective for wedging them apart sufficiently to insert thick oil warmed up just enough to make it run freely.

Aligning Gear Box and Engine.—In aligning the gear box and engine, first make sure that the gears change easily. If they do not, see that the shaft from change-speed lever to the selector is straight. If not, straighten it; but if it is, alter the position of the gear box until the speeds change easily, this possibly involving packing it up slightly.

In putting a clutch back, difficulty sometimes arises in compressing a spring sufficiently to get the nut and lock nut on, but as clutches differ so much in design the individual must use his ingenuity in this matter. It will be sufficient to point out that jacks and clamps may be very useful in this matter. As to the adjustment of the clutch, once the worker has made sure that it engages, its final adjustment can only be determined on the road. If it slips, tighten the nuts that compress the springs; if too fierce, slacken them back, but make sure that the fierceness is not caused by copper rivets standing above the leather.

Brakes.—If the brakes have proved weak on the road, and the ordinary externally accessible adjustments have proved ineffectual, their linings or brake shoes must be renewed. The latter it is cheapest to obtain from the makers. For the former, cut off and punch out the copper rivets, and rivet in place fresh lining of the same sort accurately cut.

Engine troubles at starting and on the road are dealt with on pages 195 and 196.

Sharpening and Setting Saws

Setting a Saw.—The bending of saw teeth alternatively right and left is known as "setting," and its object is to assist the teeth in cutting a clear way through the wood. A saw that gives a wide cut or "kerf" will not require setting as well as sharpening. Setting saws by placing them on an iron block and hitting the teeth with a hammer is the oldest and most rapid method, though it is only recommended for the use of the expert. The iron block is about 7 in. or 8 in. long, with the top edges bevelled off, the saw being held flat on the block with the teeth projecting over the bevel and each alternate tooth being then struck with the hammer. The saw is then turned over and the process repeated. An allied method is to use a block of hard wood and to set the teeth with hammer and punch. The average workman uses a saw-set (Fig. 1), which consists of a handled piece of steel containing a number of slots or notches. A slot is fitted over a tooth and the saw-set handle pressed downwards. Some saw-sets of this type are provided with a gauge which, when the tooth is bent sufficiently, touches the side of the saw blade, thus ensuring that all the teeth are given the same amount of set. Plunger saw-sets are also largely used (see Fig. 2). On pressing the handles together the plunger is pressed against the tooth (see Fig. 3); when the handles are released the plunger springs back. This saw-set can be adjusted for various sizes of teeth by turning the revolving disc.

Fig. 1.—Method of Using the Ordinary Notched Saw-set

Saw Vice. — The simplest device for holding the saw whilst sharpening consists of two pieces of wood, 2 in. by 1 in. thick, the length of the saw; these go into the bench vice, and the saw blade is placed between them and the vice jaws tightened up; the saw should project not more than about $\frac{1}{2}$ in.

Topping or Flatting Saw Teeth.—On sighting along the teeth of a dull saw it will be seen that the teeth are of uneven height; to top them level, run a flat file over them. The file may be fitted in a groove cut in a piece of wood, and then if this wooden guide is held against the side of the blade, the file will be kept level and do its work more accurately.

Sharpening Saw Teeth.—A three-cornered or triangular file, incorrectly known sometimes as a "three-square" file (Fig. 4), is required for the actual sharpening. It may be double-ended (Fig. 5). Saw files are made in various sizes, a $4\frac{1}{2}$-in. file being suitable for hand saws and a $3\frac{1}{2}$ in. for tenon saws. The section of the file is an equilateral triangle, and the *size* of the file will not alter the *angles* of the file, which are 60° in every case.

Begin sharpening at the handle end of the saw. The file is held level but pointing towards the handle end of the saw (see Fig. 6). The position to hold the file may be determined by laying it between the teeth so that it will file the teeth and yet preserve the former shape. File down into each *alternate* gap between the teeth until the white specks (denoting dullness) on the teeth points to the left of the file are nearly removed. Two or three forward strokes of the file will be required for each tooth. The tooth to the left of the file is the one that is being sharpened. The white specks on the teeth will be entirely removed when filing from the other side.

When the saw has been filed from one side, it is turned round and filed in exactly the same way from the other side.

Fig. 2.—Plier or Plunger Saw-set

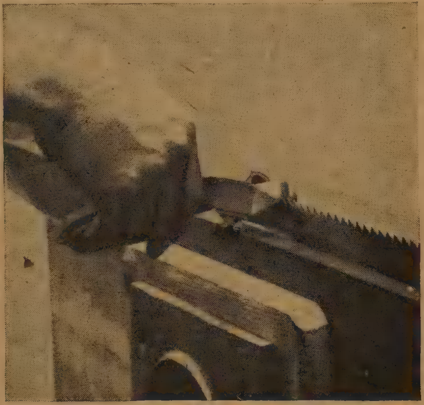


Fig. 3.—Method of Using Plier Saw-set

Fig. 6.—Method of Filing Saw Teeth : File points towards Saw Handle

Fig. 4.—Single-ended Saw File

Fig. 5 —Double-ended Saw File

A good angle for the front (leading edge) of the teeth of a cross-cut saw is about 75°. The front edges of the rip-saw teeth are at about 90° to the edge, and the angle between the teeth will be about 62°. The teeth of the rip saw are filed in the same manner as for a cross-cut saw, but the file is not pointed so much towards the handle (from 3° to 5° out of square is about right), whilst for a cross-cut, tenon, or panel saw the file should be pointed about 20° to 30° out of square. The more

the file is held out of square the finer will be the point and the keener the cutting, but the teeth will be weaker and more quickly dulled.

Saws used mostly for cross-cutting soft wood should have a fine sharp tooth, and this is obtained by holding the file more obliquely to the saw blade, say about 60° (30° out of square). For hard-wood the teeth should be less acute, and the file is held at about 70° to 75° to the face of the saw (15° to 20° out of square).

Panel, tenon, dovetail, and compass saws are sharpened as for a cross-cut saw, but it is desirable to use a little finer file.

Pad saws are made with the blade tapering quickly towards the back edge, and therefore do not require setting.

Heating over an Oil Lamp or Gas Bracket

The contrivances illustrated on this page will be found useful in the bedroom for warming shaving water, infant's food, etc.

Fig. 1.—Oil Lamp and Bracket

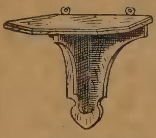


Fig. 3.—Wooden Bracket

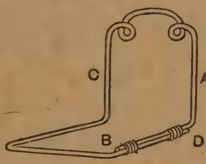


Fig. 4.—Details of Wire Bracket Shown in Fig. 1

Fig. 6.—Plan of Wires under Saucepan

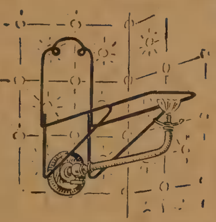


Fig. 2.—Wire Bracket and Gas-jet

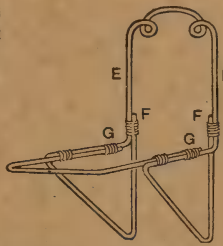


Fig. 5.—Details of Wire Bracket Shown in Fig. 2

A wire bracket for supporting a small saucepan is attached to the wall by means of two nails, and beneath is an oil lamp (see Fig. 1). In Fig. 2 is a similar bracket, but with angle stays, fixed over a gas jet. As an alternative from the hanging lamp in Fig. 1, a table lamp may be placed on a wood bracket such as shown by Fig. 3. The glass chimney should be about 1 in. below the saucepan.

The wire bracket shown by Fig. 1 is of wire about $\frac{3}{32}$ in. in diameter, or thicker. The vertical side wire A (Fig. 4) is continued to B, and C is brought to D, and the two end portions are tied together side by side with fine wire. Presuming a small saucepan is used, put in the amount of liquid generally required, and place across the wires; the weight will probably bend the wires down. Remove the pan, and bend the wires sufficiently upwards so that the pan will stand level.

The bracket shown by Fig. 2 consists of two lengths of wire, and the construction is shown in Fig. 5. The sides E are continued to F, and the front portion to G. The size of saucepan or other vessel will determine the distance apart of the wires of the bracket (see Fig. 6).

Metal-drilling Tools and How to Use Them

The operation of cutting a hole in metal or stone cannot be said to be new. In the prehistoric times a primitive form of drill was used by man when holes were desired to be made in some of the rude implements, tools, etc., that were used at that period. It is said that even at the present time a form of drill is used by some Mexican Indians that bears a resemblance to the hole-cutting tool used in prehistoric times. The tool at that period consisted of a piece of circular wood with a split at one end, into which was inserted a piece of hard flint; this end of the stick was then tightly bound with some suitable material and the other end pointed; the edges of the flint were rubbed to a point similar to the flat drill of the present time. In use the flint was placed on the material to be drilled, a piece of pebble with a small piece chipped out and rubbed smooth, held in the pointed end of the upright stick, and a bow (probably made from the branch of a tree) drawn backwards and forwards over the stick. This movement of the bow caused the drill to revolve when drawn in both directions, for which reason the piece of flint was sharpened to a scraping edge. This crude tool gave excellent results, and the modern drilling machine and the lathe have developed from it; the drilling machine can be compared to the flint drill used in a vertical position, and the lathe to the flint drill used in a horizontal position.

At the present time small drills are revolved by bows, archimedean drill-holders, whirl drill-holders, and by small drill braces. These are useful where the desired hole is not more then $\frac{1}{4}$ in. diameter. For holes larger than $\frac{1}{4}$ in., it is advisable to use geared breast drills, if a drilling machine is not available. Larger holes are generally drilled by means of power-driven machines, of which there are many varieties. However, in isolated instances, it may be necessary to use a ratchet drill. Various home-made drilling machines are described elsewhere in these volumes.

THE FLAT DRILL

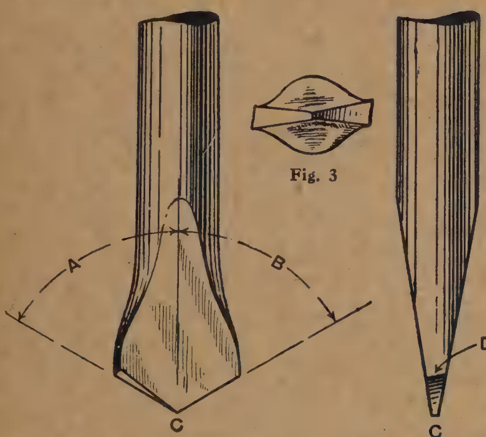
The flat drill (Figs. 1 to 3) is the type mostly used in small machine shops, and it is forged from a piece of circular bar steel. The angles A and B (Fig. 1) should be exactly equal, and the point C exactly in the centre of the drill. The clearance angles or the amount the cutting edge is backed off should be equal; the rake or clearance is clearly shown by the sloping line D in Fig. 2. The ordinary flat drill can be rotated in one direction only, but the type of drill shown by Figs. 4 and 5 can be revolved in either direction and good results obtained. The amount of material removed by a drill with a cutting edge centrally ground is naturally less than that removed by a drill with one cutting edge, as the material is removed by scraping instead of by cutting. Drills with scraping edges are greatly used by metalworkers for drilling small holes,

and are very suitable for use in either an archimedean drill or a fiddle drill. Though the scraping edge drill is rather an unmechanical tool, it is in extensive employment by workmen for drilling minute holes in all kinds of metal.

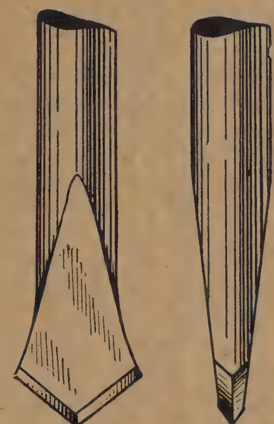
The flat drill is a very useful tool for cutting cast-iron and for work where close measurements are of little importance, but the holes drilled are never exactly round or parallel, neither are they straight. The cutting edges of the ordinary flat drill do not have sufficient rake to gave them a perfect cutting action, consequently the chips are constantly broken up and considerable force has to be applied to cause the drill to cut.

Flat drills give many different results in working; the softness or the hardness of the material may be responsible for erratic working, and the presence of blowholes in castings may cause the drill to bind and break. In a flat drill shaped as shown in Fig. 6 the radius A will regulate the diameter of the hole, and this will be much larger than the dimension B; this shape is incorrect, because the small cutting edge will do very little cutting at all, whereas it is important that the cutting edges should share the work equally.

There are cases, however, in which drills are purposely shaped as in Fig. 6. For example, it is sometimes found necessary to chamfer out a long hole in the centre; for instance, it is not good practice to fit the hole in a long sleeve or coupling for all its length, the hole being generally made larger in the middle, so that the sleeve bears on the ends only. When chamfering out a hole, it is first bored in the lathe with a correctly shaped drill (Figs. 1 to 3), and then the out-of-centre drill is inserted. This will bore out the hole larger, according to the amount that the cutting edges are out of the centre.



Figs. 1 to 3.—Flat Drill



Figs. 4 and 5.—Drill for Cutting in Two Directions

Fig. 6.—Drill with Point Out of Centre

It is usual to make the sides of a flat drill parallel for about $\frac{1}{2}$ in. in length, as shown by Fig. 7 at A and B. This portion should be curved to the radius of the hole to be cut, and, in grinding, only the edges C and D are allowed to touch the stone. If the drill is shaped as shown by Fig. 8, the diameter of the hole will decrease in size every time the drill is ground, since the sides A and B are not parallel. A further disadvantage is that the points C and D are very weak when a drill is ground in this manner, and easily get chipped, the drill being then practically useless.

The point of a flat drill should be as thin as the size of the drill will permit, for it is only a scraping edge, and if the point is of any material thickness a great effort will be required to force the drill through the work. If, however, the point is made too thin, constant trouble will be caused by the edge chipping, this necessitating frequent grinding. A groove is sometimes ground in the point of the drill (see Fig. 9) in order to remove the scraping edge that previously existed there, but as this somewhat weakens the drill such practice is not recommended.

Fig. 7.—Correctly-shaped Drill Slides

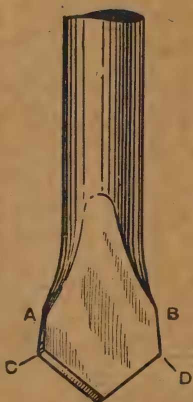


Fig. 8.—Incorrectly-shaped Drill Slides


Fig. 9.—Drill with Grooved Point


Fig. 10 **Fig. 11**
Figs. 10 and 11.—Lipped Drill

A good form of flat drill for cutting out large holes and for enlarging holes that have already been drilled is shown by Figs. 10 and 11. This type of drill, known as a lipped drill, has the cutting edge either ground in or formed in the forging. By making the cutting edge in this manner a considerable amount of rake is obtained, thus enabling the drill to cut instead of scrape. It should be remembered that sufficient metal must be left at the back of the cutting edge in order that this is strong enough to take the strain from the cutting without chipping. The writer has frequently used large lip drills for enlarging holes in mild and hard steel forgings, and if these are plentifully supplied with water they will give satisfaction. Only flat drills are here described, and, as previously explained, this form of tool will give only roughly accurate results ; if good and truly circular holes are desired, twist drills must be used.

Flat drills are usually made from round bars of steel, with the cutting end flattened out and the other end either turned or forged to fit the drill-holder. Of course the turned shank, being more round than a forged one, will give better results in use than will the forged shank. Some mechanics make good drills from worn-out files after first grinding off the teeth. This precaution is of importance, as if any grooves, such as file marks, are left in, a crack will probably result during the process of hardening.

THE TWIST DRILL

Nearly fifty years ago, both the late Sir Joseph Whitworth, the inventor of the screw-thread now in general use, and the late Mr. Green, of Leeds, manufactured some twist drills. However, these were not a success, and as a consequence few were made. Some time later the Manhattan Firearms Company of America produced some twist drills of a good finish, but they were not durable ; the two lips

were too keen in their cutting angles, and trouble was caused by frequent breakages. Mr. Morse, the founder of the famous Morse Twist Drill Company, of Cleveland, U.S.A., then took up the matter, and by diminishing the keenness of the cutting edges, adopting an increasing angle, and by marking a grinding line exactly in the centre of the drill, he produced better results than had previously been obtained. In Figs. 13 and 14 the clearance is shown exaggerated, in order that the effect may easily be noted.

As well as the parallel shank mostly used in lathes, and the taper shank (Fig. 15) always used in drilling machines, there are several special drills. The hollow twist drill (Fig. 16) has a hole cut lengthwise through the shank connecting with the flutes of the drill. The shank is some-

Fig. 12.—Parallel-shank Twist Drill

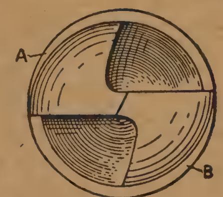


Fig. 13.—"Backing-off" of Drill

Fig. 15.—Taper-shank Twist Drill

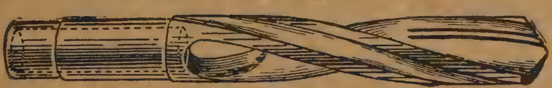


Fig. 16.—Hollow Twist Drill

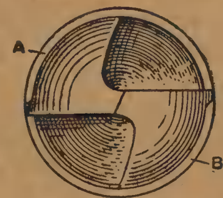


Fig. 14.—Alternative Form of "Backing-off"

Fig. 17.—Twist Drill with Lubricating Holes

Fig. 18.—Combined Drill and Countersink

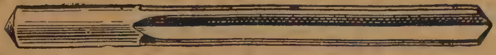


Fig. 19.—Straight-fluted Drill

Twist drills are now universally made with a constant spiral, so as to obtain a uniform cutting angle as the drill is ground shorter.

The ordinary commercial twist drill (Fig. 12) is made from round material, and has the flutes slightly backed off from the cutting edges, as shown at A and B (Fig. 13). This is done in order to prevent the drill from binding, but drills made in this manner do not give such good results as those made as shown by Fig. 14, which form of drill has clearance ground on the plates concentric with the outside of the cutting edges, as indicated at A and B. times screwed and fitted with a metal tube of suitable length. The lubricant is conveyed to the point of the drill on the outside of the tube, while the hollow tube admits of the passage of oil and chips from the point. A unique drill is often used in automatic machinery and in other machines where the work revolves and the drill does not turn. In Fig. 17 the spiral holes indicated by dotted lines are drilled in the material, before twisting, from the point to the shank, where they enter a large hole into which the oil is pumped. A special attachment in the

machine causes oil to be forced down the holes in the flutes and out at the cutting end. This method keeps the cutting edges of the drill cool, and also forces the chips upwards out of the hole.

Fig. 20.—Marking Out Circle for Drilling

In addition to the drills that have already been described, there is a number of twist drills with a special shape of shank, but as this does not affect the shape of the drill, as far as its cutting capabilities are concerned, they will not here be discussed.

The combined drill and countersink (Fig. 18) is greatly used by metal-turners for drilling the recess into which the lathe centre is placed. It will be noticed that there are two different diameters shown in Fig. 18; the small drill is for cutting a hole so that the point of the lathe centre will not bind, and to give the centre a large bearing surface. The portion of the countersink drills the part that receives the centre, the point being free from any pressure, and the centre receiving the benefit of being lubricated by the oil that has previously been placed in the same hole.

When thin sheet metal is drilled it is best to use a straight-fluted drill (Fig. 19), twist drills being unsuitable on account of the spiral flutes. If an ordinary twist drill is used it has a tendency to plunge through the material, the spiral flutes acting as a screw, as will be understood from the action of a coarse-threaded screw when passing through a nut; straight-fluted drills are also often used for drilling brasswork.

DRILLING HOLES

When it is desired to drill a hole, it is usual to "mark off" on the surface of the material the size of the hole required. A centre is first made with a centre-punch and a circle scribed round it by means of a pair of compasses, using the centre for one leg of the compass. Several small centre-punch marks are next made on the line, as shown in Fig. 20. The drill is then fed down into the centre, and a small amount of material cut away; the drill is next lifted clear of the work, and note is taken whether the outside edge of the newly drilled portion is concentric with the marked-out circle. Should it prove to be eccentric, as shown in Fig. 21, it is obvious that the centre must be drawn in order to bring the drill into correct relation with the marked-out circle. The method of doing this is indicated by Fig. 22. The groove A is cut by means of a narrow-nosed or cross-cut chisel, this enabling the drill to run towards the desired centre—that is, in the direction of the arrow. After again drilling away a small amount of material, it will be found that the drill has changed its position, and if it has not moved sufficiently, more chisel cuts must be made until it is

Fig. 21.—Diagram Showing Eccentricity of Drill Recess

brought into the correct position, as shown by Fig. 23. It must be remembered that the chisel cut is most effective when it is deep near the desired centre, as shown by Fig. 22.

In drilling deep holes it is often advantageous to drill first a small hole right

through the material (Fig. 24), in order to take the strain off the point of the drill. As already explained, the action at the point is only of a scraping nature, and if a large drill is used considerable effort will be required to force it into the material.

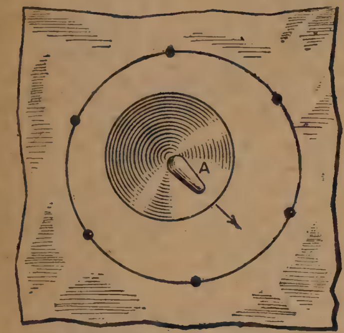


Fig. 22.—Method of Drawing Centre

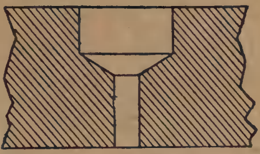


Fig. 24.—Leading Hole to take Strain off Drill Point

Fig. 23.—Drill in Correct Relation to Marked-out Circle

SPEED OF DRILLS

Regarding the speed of the drill, if no method is available for indicating the number of revolutions per minute, the condition of the cutting edges may be observed after the drill has done a little work. If the cutting edges are chipped, it is an indication that too much pressure or feed has been applied; if the corners are worn, it is an indication that the drill is revolving at too quick a speed. Of course, unless the drill is correctly hardened the above observations will be of little use, since ordinarily a hard drill would badly chip and a soft drill would badly wear. It is, therefore, essential that the drills must be correctly hardened.

SPEEDS OF ORDINARY CARBON-STEEL TWIST DRILLS

Size of drill	*Revolutions per minute*	*Size of drill*	*Revolutions per minute*	*Size of drill*	*Revolutions per minute*	*Size of drill*	*Revolutions per minute*
1/16	1834	13/16	141	1 9/16	73	2 5/16	49
1/8	917	7/8	131	1 5/8	70	2 3/8	48
3/16	611	15/16	122	1 11/16	68	2 7/16	47
1/4	458	1	115	1 3/4	65	2 1/2	45
5/16	360	1 1/16	108	1 13/16	63	2 9/16	44
3/8	306	1 1/8	102	1 7/8	61	2 5/8	43
7/16	262	1 3/16	96	1 15/16	59	2 11/16	42
1/2	229	1 1/4	92	2	57	2 3/4	41
9/16	204	1 5/16	87	2 1/16	55	2 13/16	40
5/8	184	1 3/8	83	2 1/8	54	2 7/8	39
11/16	167	1 7/16	80	2 3/16	52	2 15/16	39
3/4	153	1 1/2	76	2 1/4	51	3	38

The speeds given in the foregoing table are those recommended by one of the largest manufacturers of twist drills in the world. The feed recommended is ·004 in. to ·007 in. per revolution for drills that are smaller than $\frac{1}{2}$-in. diameter, and from ·005 in. to ·010 in. for drills larger than $\frac{1}{2}$-in. diameter.

SPEEDS AND FEEDS FOR HIGH-SPEED-STEEL TWIST DRILLS

Size of drill	*Revolutions per minute*	*Feeds*		*Size of drill*	*Revolutions per minute*	*Feeds*	
		Per rev. in in.	*Per minute in in.*			*Per rev. in in.*	*Per minute in in.*
1/4	1180	·0072	8·48	1	198	·0127	2·51
5/16	940	·0078	7·28	1 1/8	180	·0131	2·37
3/8	780	·0083	6·45	1 5/8	165	·0135	2·23
7/16	666	·0087	5·79	1 3/4	151	·0138	2·07
1/2	580	·0091	5·27	1 7/8	140	·0141	1·97
9/16	513	·0095	4·84	2	130	·0144	1·88
5/8	460	·0098	4·51	2 1/4	113	·0150	1·69
11/16	416	·0101	4·2	2 1/2	100	·0155	1·56
3/4	380	·0104	3·96	2 3/4	89	·0160	1·43
13/16	349	·0107	3·71	3	80	·0165	1·31
7/8	323	·0110	3·55	3 1/4	72	·0170	1·22
15/16	300	·0112	3·37	3 1/2	66	·0174	1·14
1	280	·0114	3·22	3 3/4	60	·0178	1·07
1 1/8	247	·0119	2·94	4	55	·0182	1·0
1 1/4	220	·0123	2·72				

The above speeds and feeds are given by the makers of the well-known "A.W." high-speed drills, and are arranged for ordinary grades of mild steel and cast-iron. When drilling brass, the speeds may be increased 100 per cent.—that is, multiplied by 2—and for cast-iron the feeds may be increased 25 per cent. for all drills above $\frac{3}{4}$-in. diameter. From the table given it appears that a $\frac{1}{4}$-in. drill will drill through mild steel at the rate of $8\frac{1}{2}$ in. per minute, and a $\frac{3}{4}$-in. drill at the rate of nearly 4 in. per minute. It must not, however, be

assumed that the speeds and feeds given in the table for high-speed drills are the maximum, for the writer has seen cast-iron being drilled at the rate of 15 in. per minute, and Messrs. Armstrong Whitworth have drilled cast-iron at the rate of 20 in. per minute. The same firm have drilled $\frac{5}{8}$-in. holes in steel plate at the rate of $10\frac{3}{4}$ in. per minute. A further example of rapid drilling has been given by a Coventry firm; in this case a $1\frac{3}{4}$ in. hole was drilled through 1 in. of steel in 28 seconds.

usual to make high-speed drills of less diameter than $\frac{1}{4}$ in., because the revolutions required for smaller diameters than that would be very great, and the cost of manufacture excessive; a $\frac{1}{4}$-in. drill requires 1,180 revolutions per minute in order to obtain good results.

GRINDING DRILLS

The angle of the cutting edges of ordinary flat drills should be about 120° (see Fig. 1, p. 331), and the angle of clearance about 3° (D, Fig. 2, p. 331). When

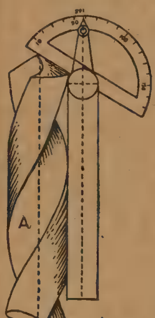
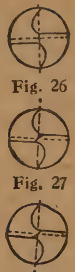


Fig. 25.—Measuring Angle of Twist Drill



Figs. 26 to 28.—Drill Points Correct, Incorrect, and with Insufficient clearance

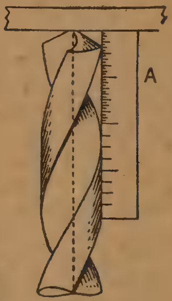
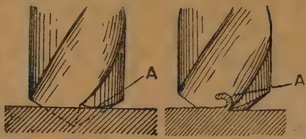


Fig. 29. Testing Height of Cutting Edges



Figs. 30 and 31.—Drills with Too Little and Too Much Clearance

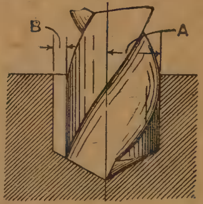
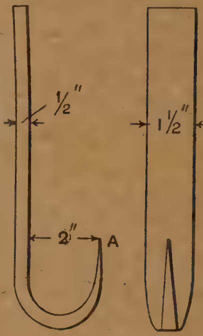


Fig 32.—Drill Ground Out of Centre



Figs. 33 and 34.—Home-made Drill Gauge

Regarding the ability of high-speed drills to stand the strain resulting from feeds and speeds as here given, it may be mentioned that 500 holes have been drilled through cast-iron 2 in. thick with a feed of 20 in. per minute with one "A.W." twist drill without resharpening. When it is remembered that only a few years ago the drilling through a $2\frac{3}{4}$-in. iron bar with a $\frac{1}{2}$-in. drill in $1\frac{1}{2}$ min. was considered a good performance, it is an easy matter to realise the importance of using high-speed drills in up-to-date engineering works. Although the cost of high-speed drills is about twice as great as that of ordinary carbon-steel drills, the extra cost is saved in a big establishment after using for a few minutes. It is not

grinding, care must be taken that the edges are ground perfectly equal each side of the centre line, so that each cutting edge does the same amount of work. Drills that are used with a scraping edge should be ground to a bevel of about 27°.

If the clearance of a twist drill is insufficient or imperfect, the tool will not cut. When force is applied the drill resists the power of the machine, and in consequence is crushed or split. It is well to start a drill by hand after grinding, observing the character of the chips, which should show if the drill is cutting correctly; in wrought-iron, when the drill is cutting correctly, the shaving will sometimes attain a length of several feet.

Drills properly made have their cutting edges straight when ground to a proper angle, which is 59°, as indicated in Fig. 25. Grinding to a less angle produces a drill that will cut a crooked and irregular hole. The grinding line (A, Fig. 25) on a drill is placed slightly above the centre, to allow for the proper angle of the point, which is an important factor; the angle is an index to the clearance. If the angle is too great the drill cuts badly; if not enough, the drill may not cut at all. Fig. 26 indicates the correct angle; in Fig. 27 the angle is too sharp; in Fig. 28 the angle runs backwards, and shows the want of clearance.

An effective method of determining the clearance is to set the point of the drill on a flat surface, holding a scale A, as indicated in Fig. 29; by turning the drill round its clearance is shown, as well as the height of the cutting lips, which height should be equal. The cutting edges should be of exactly equal length, since the effect of the inequality is doubled in working.

If a twist drill is ground as indicated in Fig. 30, no cutting will be done at all, since the part of the drill A at the back of the cutting edge touches the work first. On the other hand, if the drill is ground with too much clearance, as indicated by Fig. 31, the cutting edge A will quickly embed itself in the metal, and cause the drill to break. If the drill is ground out of centre, as shown by Fig. 32, it will be the radius A that will determine the diameter of the hole, and the space B will equal the distance or the amount that the drill is out of centre.

The amateur will probably not possess a twist-drill grinder, and in its absence he may test the cutting edge on his drill by means of the appliance shown in Figs. 33 and 34. One may be made from $1\frac{1}{2}$ in. by $\frac{1}{2}$ in. flat iron drawn down, and a point ground on at A before bending. The centre in the shank of the drill is placed on the point of the appliance, and an arc described on the flat portion with the cutting edge of the drill. Then the drill is turned round, and the action repeated. It may thus be seen whether the cutting edges are of equal heights and lengths.

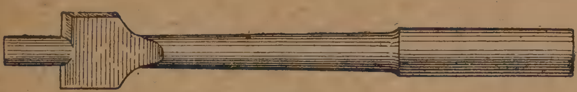


Fig. 35

Fig. 36

Figs. 35 and 36.—Pin Drill

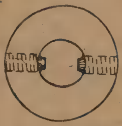


Fig. 39.—Screws in Rose Cutter

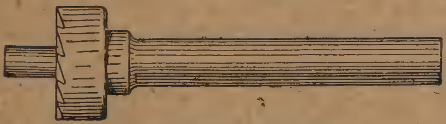


Fig. 37.—Arboring Tool

Fig. 38.—Arbor End of Spindle

Fig 41.—Radius Arbor

Fig. 40.—Countersink Arbor

OTHER SHAPES OF DRILLS

When a hole is bored through a casting or other machine part, the surface round the hole is usually arbored to form a flat, smooth bearing for the nut or bolt head to bed on, and for this purpose a pin drill (see Figs. 35 and 36) is used. The pin enters the hole, and steadies the drill. The flat cutters true up the surface, or bore it deep enough to receive cheese-headed screws.

Another form of arboring tool is shown by Fig. 37. It consists of a loose rose-head cutter, which is quickly attached to a mandrel or shank to fit the drill spindle. The lower end of the mandrel has two small keyways or grooves opposite each other, and they also turn at right angles at the top ends (see Fig. 38). The loose rose cutter is provided with two internal

projections made by tightly fitting screws, as shown in Fig. 39. These projections fit up into the vertical grooves shown in Fig. 38, and then a slight turn carries them into the horizontal grooves, the rose head being thus retained in its working position.

Other forms of rose-head cutters are shown by Figs. 40 and 41. They are used for countersinking and forming the coned seatings for small valves, etc. Fig. 41 shows a useful shape where holes have to be rounded off instead of being only countersunk. A solid head countersink is shown by Fig. 42. This tool is turned up the required size, and then divided out for eight, ten or twelve teeth, according to diameter. The cutting teeth are then filed or milled with a circular cutter, after which each tooth is carefully "backed off" or given clearance, the same as the lip of a drill or any other edge tool, but in a less degree; the clearance is distinctly shown in Fig. 42.

It frequently happens that holes are required with flat bottoms, and to effect this a flat or "bottoming" drill is used to follow after the ordinary cone-pointed drill. One form of flat drill is shown by Fig. 43. It has a short centre spur of diamond point shape, the cutting edges and sides being backed off as usual for clearance.

Another form of flat drill is shown by Fig. 44, and in general view by Fig. 45. In this case, the spur is replaced by a slot cut at an angle with the edges of the drill, so that the inner cutting lip of one side will just lap the inner edge of the opposite lip, and so leave a clean surface on the work.

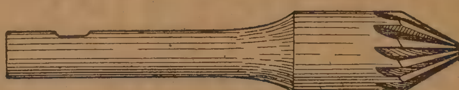


Fig. 42.—Rose-bit Countersink


Fig. 43

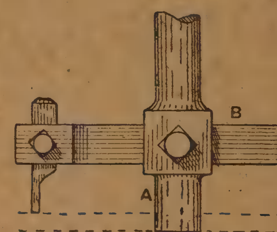


Fig. 47.—Cutter Bar for Large Holes

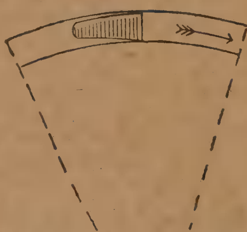


Fig. 48.—Diagram Showing Angle of Cutter


Fig. 44


Fig. 45

Figs. 43 to 45.—Flat or Arboring Drills

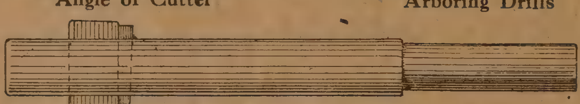


Fig. 49


Fig. 50

Figs 49 and 50.—Boring Tool

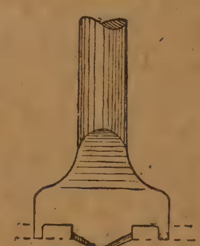


Fig. 46.—Drill for Cutting Large Holes

Fig. 46 shows a special shape drill and cutter combined, this tool being used for making thick washers from sheet-metal. The centre drill bit forms the hole, and the outer spurs or cutters determine the size of the washer. The drill shown by Fig. 43 can also be used for making holes in sheet metal. The short centre spur steadies the flat drill, which makes a rounder hole than the ordinary shape drill would in thin metal.

When large holes have to be made in

sheet metal of $\frac{1}{8}$-in. thickness and upwards, a form of extensible cutter bar, as shown by Fig. 47, is used. A centre hole of the same diameter as the pin A is first drilled in the sheet-metal, which is fitted on hardwood to the table of the drilling machine. Then the horizontal bar B containing the cutter or parting tool is set to the given radius, and clamped with the set-screws; the dotted lines indicate the metal plate. Side clearance is given on one edge only, as when a hole requires enlarging. A nicely finished hole can be made with this tool if the cutter is slightly rounded on the corners and made almost parallel on the sides.

A long boring bar is shown by Figs. 51 and 52. The bar is 1 in. in diameter, with a reduced shank to fit the drill socket. The bottom end is supported in a flanged bearing (Fig. 53), which is bolted to the table or to the base-plate of the machine.

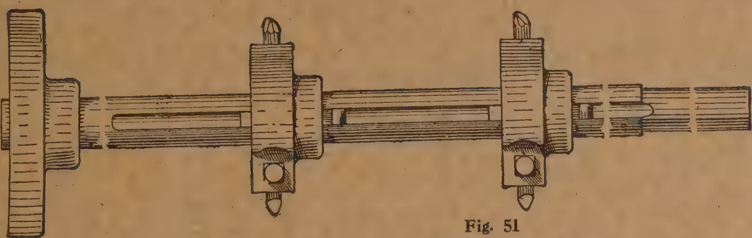


Fig. 51

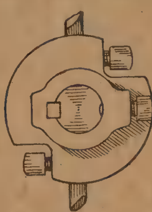


Fig. 52

Figs. 51. and 52.—Boring Bar with Two Cutter Heads

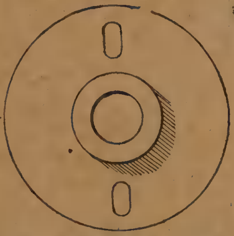


Fig. 53.—Steady Plate

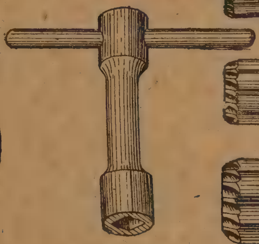


Fig. 54.—T-wrench

Fig. 55

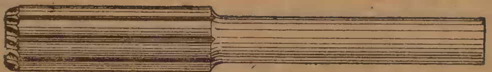


Fig. 56

Fig. 57

Figs. 55. to 57.—Rose Bits

to the cutter as shown in Fig. 48; this is important, and if neglected a breakage will occur.

The cutter bar (Fig. 49) is made from $\frac{3}{4}$-in. diameter mild steel with a parallel shank to fit the socket. Near the lower end of the bar a slot $\frac{7}{8}$ in. long by $\frac{1}{4}$ in. wide is made to receive a flat, hard cutter and wedge. These cutters are used principally for enlarging holes in castings that have been cored out in moulding. The cutter can be set to cut on both edges as shown in the end view (Fig. 50), or the same cutter may be set out so as to cut

Care should be taken not to spring the bar out of line while bolting down the bearing. It is a good plan to scribe a line deeply round the flange on to the base-plate once the bar is correctly set, so that the bearing may be quickly adjusted at any future time. The bar is provided with two cutter heads, which can be wedged in any position by suitable keys. The heads are further secured by a set-screw opposite the key. A face view of the head, with $\frac{5}{16}$-in. square cutters fixed with set-screws, is shown by Fig. 52. A T-socket wrench is more useful than an

open-jawed spanner for these small square-head set-screws, and a suitable wrench is shown by Fig. 54.

This cutter bar is used for boring out work of awkward shape, or work which it would be impracticable to chuck on the lathe. The cutter bar is entered through the work to be bored out and into the steady plate. The latter should be over a hole large enough for the bar to pass through freely, as it is fed by the hand wheel during the boring. The work is chucked or bolted to the table or the base-plate, being, of course, set accurately to the guide circles on the casting, and truly concentric with the boring bar.

When holes in machinery are required to be smooth and to be a standard size, the drills slightly under the finished size are used to bore the holes, and are finished to standard size with rose bits as shown by Figs. 55 to 57. These are $\frac{3}{8}$ in., $\frac{3}{4}$ in., and $1\frac{1}{8}$-in. in diameter respectively. The bits are turned up ·004 in. over gauge size to allow for subsequent shrinking and lapping down after hardening. There are six flutes parallel with the axis (see Fig. 58). The teeth are spaced out and filed six, eight, or twelve, according to the diameter of the bit, and must be backed off to give clearance, as previously described for the loose rose-head cutters.

The enlarged end view of a rose bit is given in Fig. 59. This type of bit works very well, and turns out good work when new; but after several dozen holes have been rose-bitted out, the bit begins to show signs of wear, and is no longer fit to make holes of a standard size where extreme accuracy is required. Another defect is in the large amount of best steel required for a full set of reamers or bits. The first defect is set right by heating and upsetting the end, skimming up in the lathe, re-cutting, and hardening the teeth again, which means practically the labour of making a new bit.

REAMERS

The reamer—known also as rimmer, rhymer, etc.—is a tool for truing or enlarging a hole and bringing it to its final shape. The old-fashioned reamer or broach was simply a tapering tool with many sides which was rotated in the hole, the edges scraping away the metal. The solid fluted reamer was a better tool, the flutes being backed off to give clearance. Simple flat-sided reamers, which answer very well for a variety of jobs, are really broaches, and have not much in common with the modern shell reamer, which is drilled out to fit a mandrel on which it is used. Shell reamers (see Fig. 60) are made in sizes from $\frac{1}{2}$ in. upwards, advancing by $\frac{1}{16}$ in., and there is usually one mandrel (Fig. 61) to six shell bits. The shells are fitted on the small end of the mandrel, and are driven by the two projecting pegs which engage in the slots made in the shells. The shoulder on the mandrel takes the thrust of the cut, while a cheese-head set-screw retains the shell on the mandrel.

To overcome a difficulty of reamers or rose bits wearing and becoming less than gauge size, the expanding blade shell reamer (Fig. 62) was devised. These reamers are not made in the smaller sizes, as it would be impracticable to do so. In the reamer shell are spaced and formed six longitudinal grooves having a very slight taper, and with a very slight undercut or dovetail in the grooves. In the latter the steel cutter blades are tightly fitted (see enlarged end view, Fig. 63). As wear takes place, the blades are touched up on the oilstone, and forced farther up the grooves. The taper in them forces out the blades a little more; the limit of expansion is ·004 in. to ·008 in., according to the size of the shell. When the blades are much worn new ones can be inserted at small cost. Fig. 64 shows a hand reamer of the expanding type on similar lines to those already described.

HARDENING AND TEMPERING DRILLS

It is usual for twist drills to be bought already hardened and tempered, owing to the difficulty that is experienced in so tempering the drill that the required hardness is equal all along the length. The hardening of a twist drill is a complicated operation, since care has to be taken that the steel is uniformly heated, and that

the tool is not allowed to warp. The drill is generally rotated, after which it is fitted in an appliance to keep it revolving while being quenched in water or other suitable liquid. Twist drills are often tempered in a bath of oil; many manufacturers use other methods, which they prefer to keep secret.

Flat drills are hardened at the cutting edge only, and it follows that as the drill wears or breaks it must be re-hardened and tempered. The heat treatment for flat drills is as follows: The point is cutting edges the drill should immediately be cooled.

The method employed by an expert in hardening and tempering flat drills is as follows: The drill is heated to a bright red heat for a length of about 4 in. from the cutting end, and about $\frac{3}{4}$ in. of the point is immersed and kept moving in cold water for a sufficient length of time to quench the material at the point only. The scale is then quickly rubbed off with a piece of hard stone, in order to brighten the steel, and then the drill is taken into

Fig. 58.

Fig. 59.

Figs. 58 and 59.—Section and End View of Rose Bit

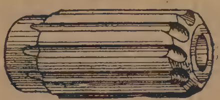


Fig. 60.—Shell Bit

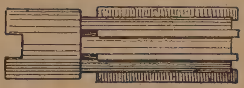


Fig. 62

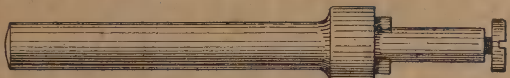


Fig. 61.—Mandrel for Shell Bits

Fig 63.

Figs. 62 and 63.—Shell Bit with Expanding Blades

Fig. 64.—Expanding Reamer

heated to a bright red heat on the forge or by other available means, and the drill is then dropped into clean water. This hardens the tool and makes it too brittle for use, and it is therefore necessary to temper it—that is, lower the degree of hardness and make the cutting edges softer. For this reason the drill is placed on a piece of red-hot iron or steel, and immediately the desired colour appears at the cutting edges it is quickly dropped into cold water. The colours obtainable range from a very pale yellow to a deep blue, the former colour denoting hardness, the latter indicating softness; the usual colour for drills is dark straw yellow, and when the steel shows this colour at the a good light and the colour observed as the heat from the remaining hot portion passes down towards the point. When the desired colour reaches the point the drill is quickly plunged into cold water and kept moving.

This method has the advantages that the hardening and tempering can quickly be done, that the drill need not leave the hand after heating, and that no heating of an extra piece of iron or steel is necessary. It must, however, be remembered that the drill end must at first be held in the water for a very short time, but long enough to quench the point, and that the colours are observed in the daylight (this also applies to the other method described),

and that no time is lost when the drill is finally quenched. The colours move so rapidly down the steel that a few seconds' delay in cooling will cause the drill to become too soft. Another point to remember is that if the point of the drill is held in the water very long at the first quenching the colours will not appear at all. Though the last-mentioned method of hardening and tempering has the merit of simplicity, the correct treatment can be acquired only by experience.

EASY METHOD OF MAKING SMALL DRILLS

Most amateur mechanics who have to drill small holes ordinarily use the fiddle or archimedean drill, in which the drill revolves first in one direction and then the opposite. This is a slow process, because it is impossible to grind a drill with cutting edge to cut in both directions. In fact, such drills do not cut; they simply scrape the metal out of the hole they make. The American twist drill is a good drill, but when less than $\frac{1}{16}$ in. in diameter it is not satisfactory. In fact, under $\frac{1}{8}$ in. the groove in the drill weakens it to such an extent that it is practically useless for rapid work.

The following is a method of making small drills that cut beautiful holes, drill rapidly, and stand well in cast-iron, steel, brass, etc. Break off a piece of a knitting needle about 2 in. long in the following manner. Place the needle in the vice in a vertical position, letting it stand 2 in. above the jaw of the vice. Then, with a small pair of pliers, take hold of it just clear of the vice jaw, give it a sharp twist as if bending it at right angles, and it will then snap off clean. Next take a piece of copper wire, say 12 in. or 1 ft. 6 in. long, about No. 20 gauge, clean it with a piece of emery-cloth for about 6 in. at one end, and tin it. Take the piece of steel, and place in the vice in a vertical position, projecting $\frac{7}{8}$ in. above the top of the jaw and $\frac{3}{4}$ in. from the side. Now take a french nail, and give the tinned end of the wire a turn close under the head of the nail. Then give the wire a twist, so as not to come off the nail. Pass the wire through the jaw of the vice, bringing the wire close up to the needle; take up the slack, then proceed to wind the wire round the needle until $\frac{1}{16}$ in. from the top. Now take it out of the vice, and cut off the ends of the wire. Then remove the wire from the needle, which can be easily done by holding the needle with a pair of pliers and taking the wire between the finger and thumb, giving the pliers a slight twist. Then trim up the end of the wire with a small file, removing the burrs, etc. Now replace the wire, taking care that it is put on in the same way as before, as this end of the needle is slightly tapered. When replaced, apply a little soldering fluid, and with a hot soldering bit give it a touch on the wire; the hot bit will not affect the cutting end of the drill, because the pliers keep this end cool.

Now with a small file trim off the superfluous solder until it just shows the copper wire. Then grip the slightly projecting end on a grindstone; next the cutting end of the drill, first by grinding a flat on each side, and then by pointing in a similar manner as in grinding a larger-size drill; but do not touch it on the side.

The object in placing the copper wire round the drills is to prevent them slipping, because, being such small drills and highly polished, they have a great tendency to slip, especially if there is not a good chuck for holding them. No tempering is required.

Building a Portable Span-roof Greenhouse

FIGS. 1 to 12 illustrate generally and in detail the const uction of a span-roof greenhouse which possesses some points of merit: it does not need to be built into the ground and is thus a tenant's fixture (it should rest upon a row of bricks without mortar), and, in addition, the removal of a few screws allows of the structure being separated into six main pieces—front, two sides, end, and two half spans, so making the greenhouse essentially portable. The most suitable timber for the work is good red deal. The quantities of materials for the house are as follow:

Boarding $\frac{3}{4}$ in. by 6 in. by 54 ft.; sash bars, $1\frac{1}{8}$ in. by $1\frac{1}{2}$ in. by 123 ft.; door frame, 3 in. by 3 in. by 16 ft. 6 in.; sill, 2 in. by 2 in. by 30 ft.; bead for door, $\frac{7}{8}$ in. by $\frac{1}{2}$ in. by 30 ft.; side and top stiles, $3\frac{1}{2}$ in. by $1\frac{1}{2}$in. by 43 ft.; end tiles, $2\frac{1}{2}$ in. by $1\frac{1}{2}$ in. by 23 ft.; bottom rails, $4\frac{1}{2}$ in. by $1\frac{1}{2}$ in. by 30 ft.; top rails, $2\frac{1}{2}$ in. by $1\frac{1}{2}$ in. by 30 ft.; muntins, $2\frac{1}{2}$ in. by $1\frac{1}{2}$ in. by 27 ft.; bottom rails of top light 4 in. by $\frac{3}{4}$ in. by 21 ft.; top rails of top light, $4\frac{1}{2}$ in. by $1\frac{1}{2}$ in. by 21 ft.; frame under light, 2 in. by $1\frac{1}{2}$ in. by 4 ft.; bottom rail O (Fig. 5) $4\frac{1}{2}$ in. by 2 in. by 30 ft.; door bead, $1\frac{1}{2}$ in. by $\frac{1}{2}$ in. by 12 ft.; ridge, 5 in. by 1 in. by 9 ft.; door stiles and top rail, 3 in. by $1\frac{1}{2}$ in. by 14 ft. 6 in.; door, middle and bottom rails, 6 in. by $1\frac{1}{2}$ in. by 5 ft.; door muntins, 3 in. by $1\frac{1}{2}$ in. by 2 ft.; door panels, 9 in. by $\frac{1}{2}$ in. by 3 ft. 6 in.

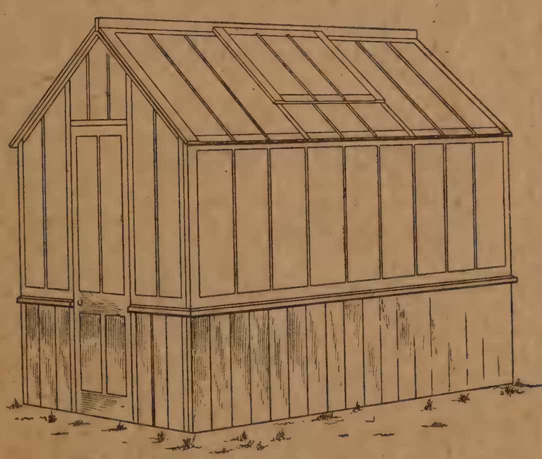


Fig. 1.—Portable Span-roof Greenhouse

Sides and Ends.—Fig. 4 shows that the sides are each formed of two main stiles, the top rail of the side-light, the bottom rail, and two stout bars A and B. The lower part of the structure is matchboarded. For marking out, the four stiles may be placed on each other in pairs, and the four marked down at once for the mortises as shown in Fig. 7. The exact positions for the joints of the stiles and rails are shown in Figs. 8 and 10.

The two top rails and the two bottom rails of the side-lights can be placed on each other and set out for the shoulders of tenons at each end, and the two stout bars

and the intermediate bars may be set out from these. The shoulders of the rails must be long enough to fit into the rebate and over the chamfers.

All the bars are now placed together and squared across at each end for length. It is best to mortise the top and bottom rails, so as to allow the tenons of the bars A and B to pass in about 2 in. The finished forms are shown at B C and D, (Figs. 8 and 10). It is a good plan to rebate the stiles their whole length, the

Fig. 2

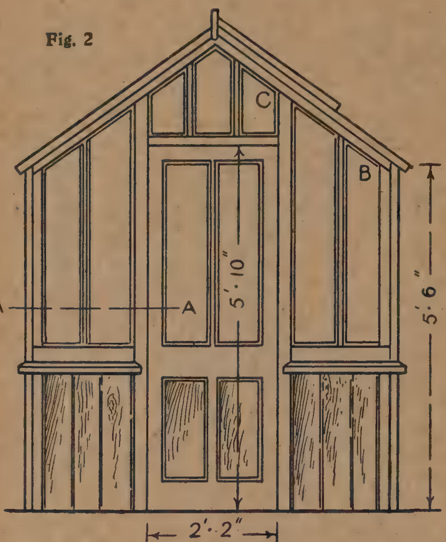


Fig. 3

Figs. 2 and 3.—Two End Elevations of Greenhouse

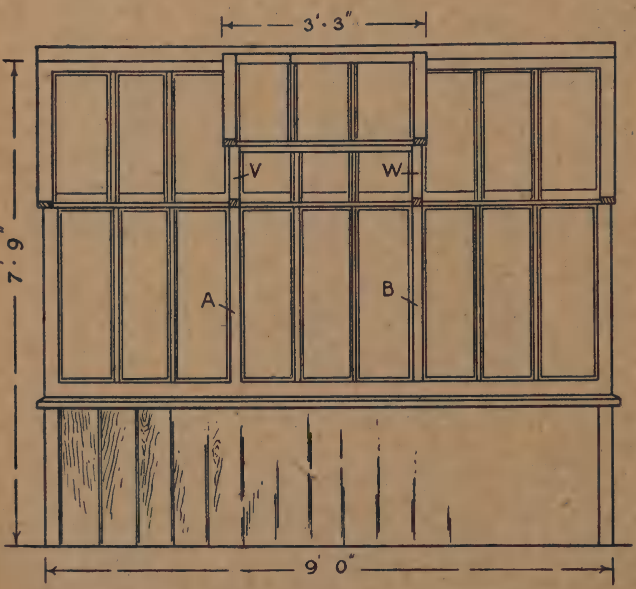


Fig. 4.—Side Elevation of Greenhouse

upper part to receive the glass and the lower part to receive the matchboarding (see E and F, Figs. 8 and 10). The lower outside edge of the bottom rail of the side-lights should also be rebated as indicated at G (Fig. 5).

In making the back end (Fig. 3), the two stiles and the bottom rails of the sash are set out for mortising and tenoning, as described for the sides. The bottom rail is set out and mortises are made for the bars. These joints having been made, the stiles and rails should be fitted together, the two top slanting rails laid down on the framing in their respective positions,

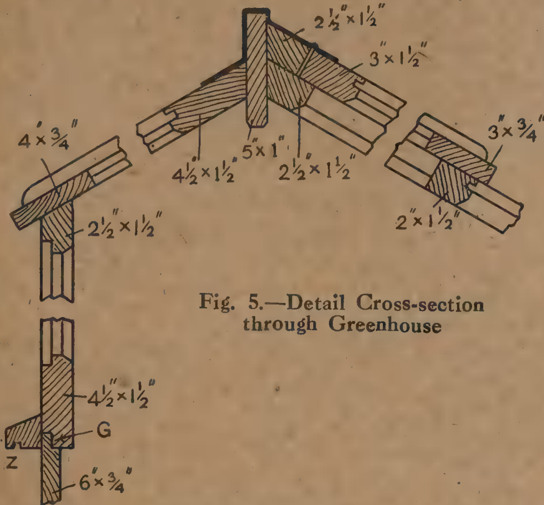


Fig. 5.—Detail Cross-section through Greenhouse

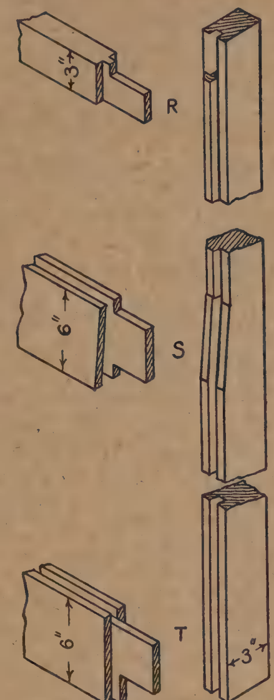


Fig. 6.—Door Joints

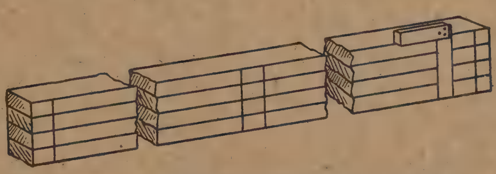


Fig. 7.—Setting-out Stiles uf Sides

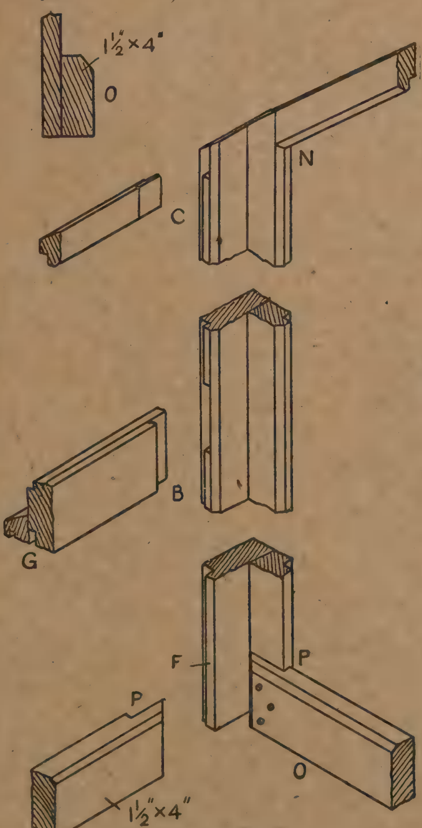


Fig. 8.—Angle Joints

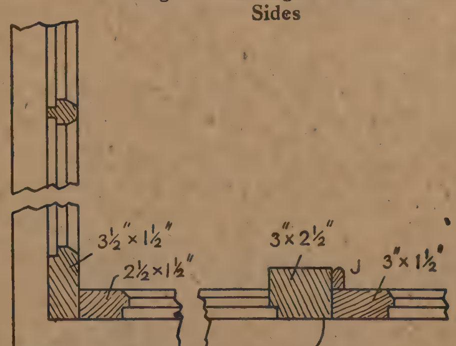


Fig. 9.—Part Horizontal Section through Greenhouse

and the shoulders marked off for tenoning to the rails and the positions of the mortises in the stiles indicated. These are the joints at H, K, and L (Fig. 3), isometric views of H and L being shown at M (Fig. 11) and N (Fig. 8). These joints having been made satisfactorily, the stiles, bottom rails, and top rails should be rebated and chamfered, after which the whole skeleton frame should be put together and kept quite square, when the position for the mortises of the bars in the top rails can be marked out. Next, the bars can be laid over the position they are to occupy, the shoulders marked off on them, and the tenons made to these. Now make the mortises for the bars in the top rails; then the complete end with bars can be put together, the joints first being well painted. Where the joints go right through, they can be wedged; in other cases it would be best to secure them with a couple of screws inserted from the back.

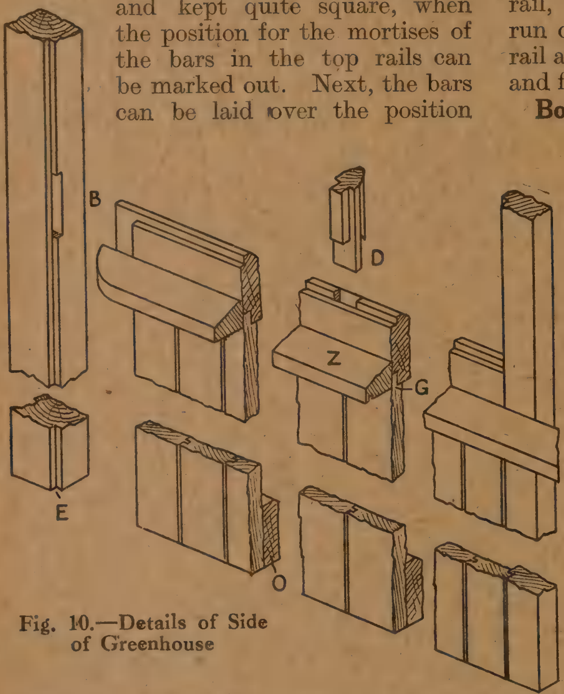


Fig. 10.—Details of Side of Greenhouse

Skylights.—In setting out the mortises and tenons for the stiles and rails of the skylights, the chief point to notice is the joint between the bottom rail and stiles (see Z, Fig. 12), where the thickness of the bottom rail is less by the amount of the depth of the rebate than that of the stiles. The skylight on the right-hand side of the house has two stout bars V and W (Fig. 4), with a cross-bar tenoned into them, so as to form an opening for the small ventilating skylight. The top ends of the bars are tenoned into the top rail as shown at X (Fig. 12), whereas at the bottom end the square of the bar is forced into a socket made in the bottom rail, the glazing fillet being allowed to run on almost to the edge of the bottom rail as at Y. The joints should be painted and fixed together

Bottom Rail, etc.—The bottom ledge or rail O (Figs. 5, 8 and 10) should be shouldered on to the stiles, so that the distance on the outside of the rail is just the thickness of the matchboard behind the face of the stiles. This notching out will be understood from P (Fig. 8), the ends being in all cases mitred and secured to the stiles by three or four stout screws.

The top ends of the matchboard should now be rebated at the back so as to fit into the rebate formed in the bottom rail G (Figs. 8 and 10). The matchboards having been carefully fitted in should be fixed in position by driving $1\frac{1}{4}$-in. nails obliquely into the bottom rail of the light, the bottom ends being nailed to the rail O in the ordinary manner. Painting all the joints of the boards before fixing them in position will add to their weathering properties.

The next procedure will be to plane off all the joints flush. Then the sides and ends should be secured together by about five 3 in. stout screws. The top rails can next be planed off flush with each other.

Ridge and Skylights.—The ridge can next be prepared and notched over the top rails at each end. This done, the upper edges of the skylight can be bevelled off and fitted to the sides of the ridge. The skylights may be secured to the sides and ends either by screwing from the outside or by inserting screws obliquely through the top rails of the

sides and ends. For purposes of portability, brass screws will be found far superior to steel screws. The joints between the ridge and skylights can be made water-tight by fixing on a capping of zinc, lead, or even felt, as illustrated in section by Fig. 5.

The small skylight, the making of which does not call for special mention, should next be hinged in position, and a suitable stay for opening provided and fixed.

Sills.—The sill piece Z (Fig. 10) can be made from a piece of stuff about $1\frac{3}{4}$ in. square, the top side being splayed and the under side having a groove or throat made in it so as to prevent rain trickling down the surface of the matchboarding. These sills are mitred at the angles, and the two ends by the side of the door opening are rounded.

Door, etc.—The lower half of the door has panels, the upper part being prepared for glass. The most difficult part in constructing will be the joints where the middle rail meets the stiles, the shoulders being splayed. The upper half is chamfered and rebated, whilst the lower part of the stile is kept of full breadth. The chamfers and rebates near the shoulders require careful working with a chisel for a distance of 4 in. or 5 in., the remaining portions being worked in the ordinary manner.

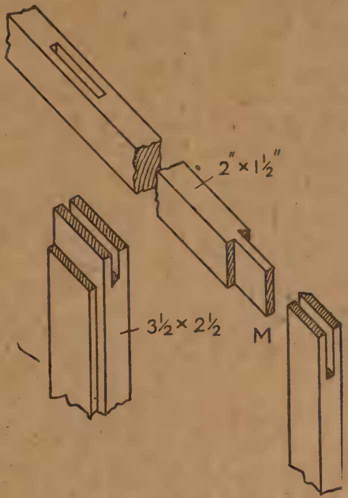


Fig. 11.—Joints at B and C (Fig. 2, p. 344)

The middle rail, with mortises and tenon having splayed shoulders, is shown at S in Fig. 6. The joints of the top rail R and bottom rail T should present little difficulty. The edges of the door should be planed so as to fit in between the frame, having a space all round of about $\frac{1}{8}$ in. When this is satisfactorily done, a pair of $3\frac{1}{2}$-in. wrought-iron butt hinges should be let in, half into the door stile and half into the post. A piece of prepared bead, illustrated by the section at J (Fig. 9), acts as a stop to the door. A small rim lock may be fitted if desired.

All the woodwork should be painted with a good coat of lead priming, after which the glazing should be done, the house being finished with two coats of oil-paint of good quality.

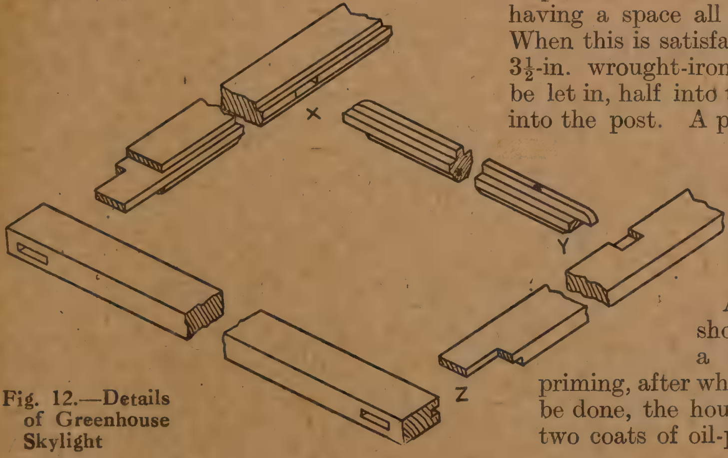


Fig. 12.—Details of Greenhouse Skylight

Furniture and Fitments

AN ANGLE WARDROBE FITMENT

The arrangement of a triangular shelf supporting a curtain across the angle of a room is by no means an unusual method of making good a deficiency of cupboards or of utilising an odd corner otherwise wasted. Such a contrivance will be described in this chapter, and the endeavour has been made to produce a fitting that, without being difficult or costly to make, is of more presentable appearance than is usually the case.

The general idea will be apparent on reference to Fig. 1. The lower shelf (A, Fig. 4, B, Fig. 2) is made up of $\frac{3}{4}$-in. or $\frac{7}{8}$-in. stuff in the form of a right-angled triangle, 3 ft. $1\frac{1}{2}$ in. along its longest side, supported on fillets (as C, Fig. 3) fixed to small plugs driven into the wall, or alternatively on pieces fixed in the same way, but 5 in. in height, thus allowing for coat-hooks, etc., to be screwed to them. At a height of 1 ft. $0\frac{1}{2}$ in. above this shelf is fixed a second one, whi h could in most cases be of lighter stuff (D, Fig. 3), fixed on small fillets as before, and measuring only 2 ft. 9 in. on the face. This shelf is finished along the front with a moulding about 4 in. by $1\frac{1}{2}$ in. (two suggestions for the section of which are shown in Figs. 5 to 7), splayed off at an angle of 45° at each end in order to fit closely against the walls.

Fig. 1.—An Angle Wardrobe Fitment

The top shelf—or, rather, the moulding along it—is supported from the lower one by means of six uprights 12 in. long by about 1 in. thick, and of the face widths and distances apart indicated in Fig. 5, where the diamond-shaped piercing suggested for the two wider of the uprights is also shown. The end upright at each side

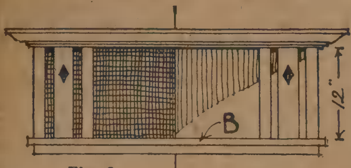


Fig. 2

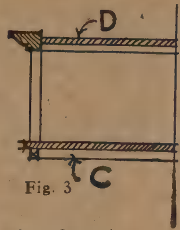


Fig. 3

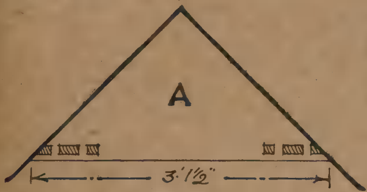


Fig. 4

Figs. 2 to 4.—Elevation, Section, and Lower-shelf Plan of Angle Fitting

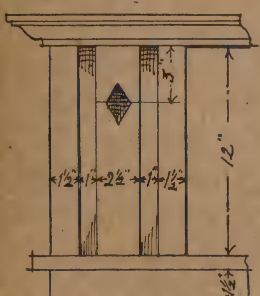


Fig. 5

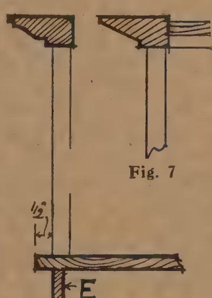


Fig. 6

Fig. 7

Figs. 5 and 6.—Part Front View and Part Section Enlarged

Fig. 7.—Alternative Design for Moulded Cornice

should be splayed off to fit closely to the wall face in a similar way to the cornice moulding. Under the lower shelf, with its face in the same plane as these uprights, and splayed at its ends as before, should be fixed a strip $1\frac{3}{4}$ in. by $\frac{5}{8}$ in. (as at E, Fig. 6), in order to screen a small rod, upon which the curtain, or curtains, can be arranged to slide in the usual way.

All the work will be seen to be extremely simple in character, and if it be preferred to take rather more trouble over it, the pieces constituting the triangular shelves might be tongued together; the fillet (E, Fig. 6) might be grooved into the under-side of the lower shelf, and the six uprights could be stub-tenoned or housed at their ends. The height at which the fitting is placed must depend entirely upon individual requirements, although should the room be furnished with a picture-rail it would be desirable that this should continue along the top shelf, if possible, in place of the cornice moulding.

A BEDROOM RECESS FITMENT

A simple fitment suitable for the recess at the side of a fireplace consists, as in Figs. 8 to 14, of a low box forming a seat, there being at a height of about 7 ft. a shelf finished with a cornice and shaped arch or spandril piece on the front, and having a sliding curtain behind the arch to screen a row of pegs fixed on the wall.

Dealing with the shelf part, which could be used independently of the seat if preferred, it can be suitably fixed at, say, a height of about 7 ft. or more, according to the scale of the room, and it will con-

Fig. 8.—Bedroom Recess Fitment

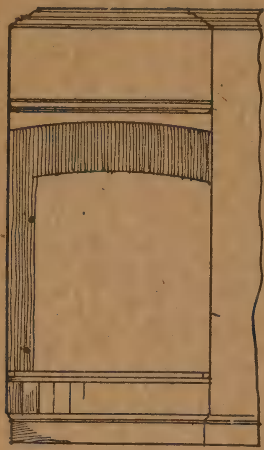


Fig. 9.—Front Elevation of Fitment

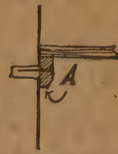


Fig. 11.—Detail of Shelf Support

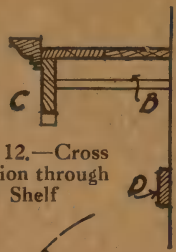
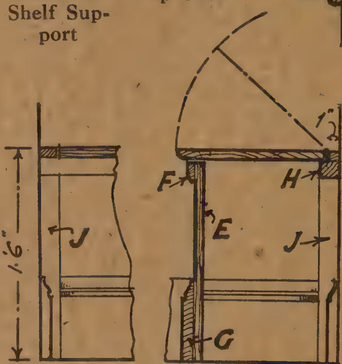


Fig. 12.—Cross Section through Top Shelf



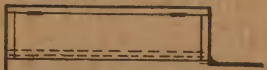
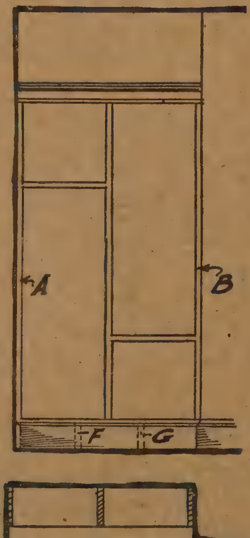


Fig. 10.—Plan of Seat

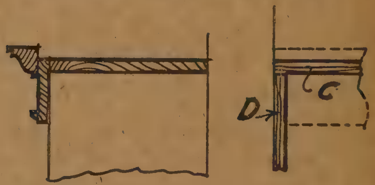
Figs. 13 and 14.—Part Elevation and Section of Lidded Seat

sist primarily of a light shelf, made up of two pieces if necessary in order to make the width as great as possible, and supported on fillets nailed to wooden plugs driven into the wall, as at A and B, Figs. 11 and 12. The arch piece should be of a very flat curve and about 1 in. by $5\frac{1}{2}$ in., fitting closely to the wall at its ends, and screwed to the fillets and shelf; it is shown in section at C in Fig. 12, which also indicates the position for a length of suitable cornice moulding which is planted on along the top as a finish, although, of course, if the room happens to have a picture moulding or frieze rail, it will be better to arrange the work at such a level that the moulding will continue across it, instead of employing a cornice. There is a plain, chamfered rail on the wall at D (Fig. 12), to which suitable pegs are screwed at regular intervals. The seat is shown in plan by Fig. 10, enlarged detail sections being shown by Figs. 13 and 14. The front E is composed of vertical V-jointed and tongued boarding, held together by means of a small strip, with one edge chamfered, fixed along the top F, and secured next the floor by a length of skirting G, either made to match that of the room or alternatively kept quite small and plain.

The top or seat should be about $\frac{7}{8}$ in. thick, and is explained in Fig. 10, where the lid portion is shown hinged to a strip at the back, and prevented from scraping the wall at the ends in raising by two other small strips running from front to back. The



Figs. 15 and 16.—Front Elevation and Plan of Another Recess Fitment



Figs. 17 and 18.—Two Cross Sections through Top Shelf

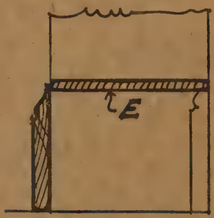


Fig. 19.—Cross Section through Bottom Shelf

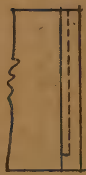


Fig. 20.—Plan Showing Suggested Method of Housing Ends of Shelves

front edge can suitably be rounded off or moulded, and it will be apparent that, assuming the seat to be supported along its front and back edges, it can safely be left to carry itself at the ends. Reference to Fig. 14 will show that the front edge receives adequate support right along as at F, while the back has a horizontal bearer H carried on, say, three uprights, as at J J; these uprights will probably require to be cut out to fit over the existing skirting at the back of the recess. If the bearer H is $\frac{1}{2}$ in. wider than the strip to which the lid is hinged, then, when the latter is closed down, it will have a continuous support along the back through resting for half an inch on the bearer H.

All the work as described above has been kept as simple and free from all complications as possible, but should the reader desire some elaboration, he can substitute a panelled front, fit a lock and key, or carry out several other possible developments of the same idea.

ANOTHER BEDROOM RECESS FITMENT

The fitment shown by Figs. 15 to 21 is designed for a similar position to the other; or it could go in the recess on one side of a fireplace, and that already described in the other. The remarks previously made as to a continuation of the existing skirting, if possible, across the base, and the utilisation of a picture-rail if this is fitted, apply equally in this instance; and taking into consideration the effect obtained, there will be found to be very little labour involved in the production of a sound and pleasing piece of work. First of all, the width of the various shelves and supports must be decided upon, and a couple of uprights about $\frac{3}{4}$ in. thick as at A and B (Fig. 15) prepared and placed in position, starting immediately above the skirting, and care being taken that their top ends are quite level. Resting on these ends will be required a light top shelf as C in Fig. 18, where D is the end of one of the two uprights; the latter are proposed to be kept apart at the bottom by a shelf as at E (Fig. 19), which fits between the inner faces of the uprights, and can be of quite thin stuff, as it is intended to be firmly supported at very close intervals by short uprights, as shown by dotted lines at F and G (Fig. 15). Reverting to Fig. 19, it will be seen that this shelf comes partly below the top edge of the skirting, which is taken across the front in order to form a

Fig. 21.—The Second Recess Fitment

kind of plinth; probably the edge of the shelf or the top of the old skirting will have to be taken off to allow a proper fit next the wall face. The internal divisions consist, of course, only of the central upright and two shelves, each appearing in one half only of the recess; the one is placed at a distance from the top equal to the height of the other from the bottom. These three pieces should be fairly substantial, at least 1 in. thick, and for a

rather primitive class of job it is possible to fix them securely merely with the ends butted against the other parts. Housing is, however, a much better form of construction, its only drawback being a slight tendency to unsightliness on the face edges, an objection that can be overcome without much trouble by housing the horizontal piece into the vertical piece in the way in Fig. 17, fixing a suitable moulded capping partly on and partly above this, and a very small bead or fillet about $\frac{1}{8}$ in. up from the bottom of the strip.

There will be no special difficulty connected with the painting or staining of the work, or arranging sliding casement curtains to the front of the long openings,

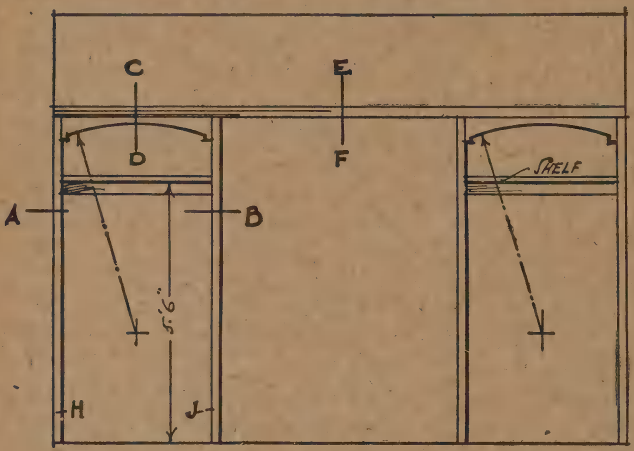


Fig. 22.—Front Elevation of Open-fronted Cupboards and Central Recess

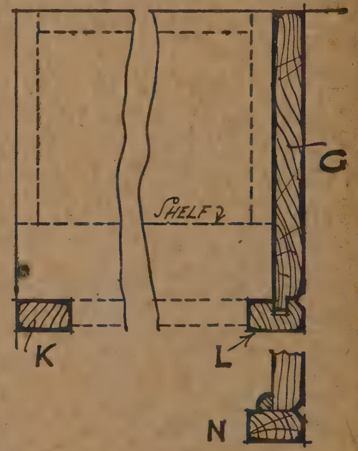


Fig. 23.—Horizontal Section through Cupboard at A B (Fig. 22)

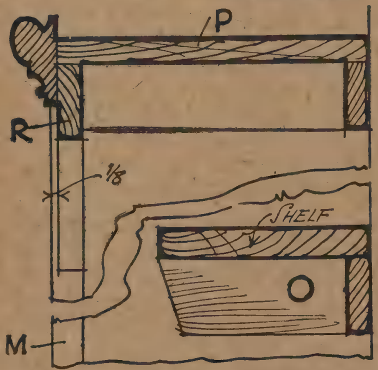


Fig. 24.—Vertical Section at C D (Fig. 22) and through Shelf

Scale for Details

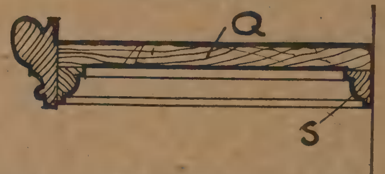


Fig. 25.—Vertical Section at E F (Fig. 22)

which could have clothes-hooks fitted on the walls or tops if required.

shown by the dotted line in Fig. 20; that is, by stopping the housing about $\frac{1}{2}$ in. back from the face, which then only shows a straight joint.

A finish is imparted to the whole by planting a small strip, say, $3\frac{1}{2}$ in. or 4 in. deep, and $\frac{1}{2}$ in. thick, along the top, as

OPEN-FRONTED CUPBOARDS TO FORM A CENTRAL RECESS

A room having a rather bare appearance is easily improved by means of a fitment of the type shown in Figs. 22 to 26; open-fronted cupboards enclosed by means of a sliding curtain—one at each side of the end wall of the room—provide a central recess which may accommodate the head

of the bedstead. This arrangement will be found to have quite a pleasing effect, and if the capping shown can be arranged as a picture or frieze moulding continued round the room, so much the better. The widths and heights must be left to the discretion of the craftsman; a recess about 5 ft. 6 in. or 6 ft. wide leaves sufficient space at each side of an ordinary upper end by the other parts of the work. On the face are two upright strips as at H and J (Fig. 22), K and L (Fig. 23), and M (Fig. 24), each about $1\frac{1}{2}$ in. by 1 in., and the same height as the side; H is fixed to the wall, and cut out to fit over the skirting board (the side will also need the same treatment), and J is fitted to G at right-angles by a tongued and grooved joint as

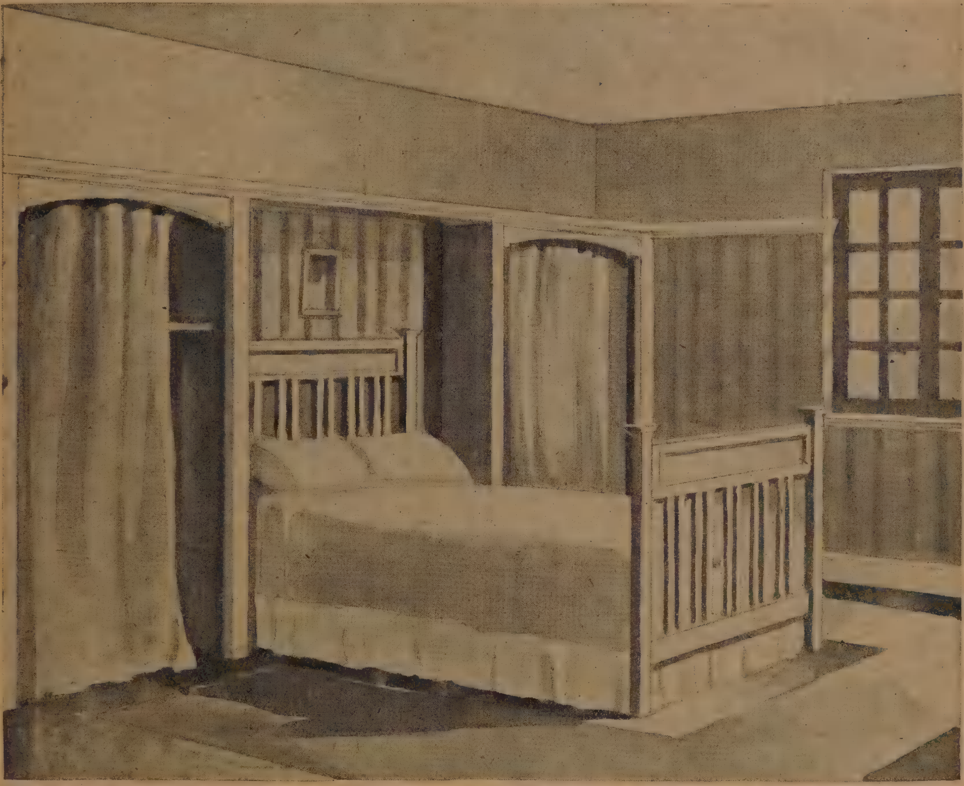


Fig. 26.—Open-fronted Cupboards forming a Central Recess for Head of Bedstead

double bed, while twin bedsteads would require rather more; the height might be arranged to match that of the doorway.

The woodwork at each end consists, first of all, of a side G (Fig. 23), about 9 in. wide and 1 in. thick, either all in one piece or made up of two or three widths of **V**-jointed and tongued boarding. This will be fixed to the floor if necessary with a small angle-bracket, and held firm at the at L (Fig. 23), or butted and fixed with a small angle-bead on the inside, bradded to both pieces, as shown at N below this figure. In either case a **V**-shaped sinking is advised as shown, in case the junction between the two pieces should open.

The work will be largely held in position by the shelf shown as being at a level of 5 ft. 6 in. above the floor, and supported on three fillets, two of them strongly fixed to plugs driven into the wall if necessary,

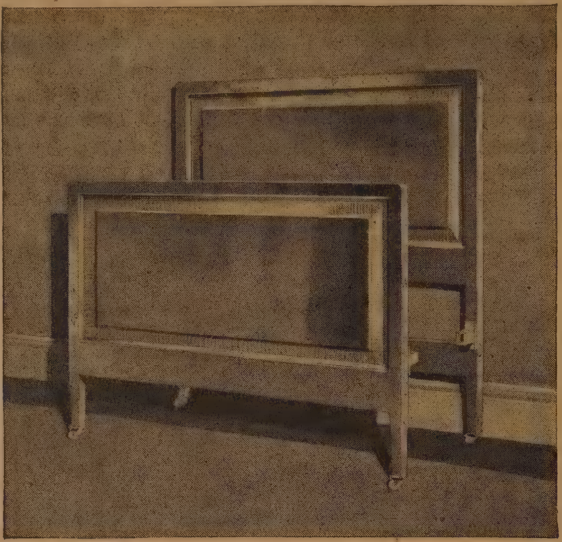


Fig. 27.—View of Head and Foot of Bedstead

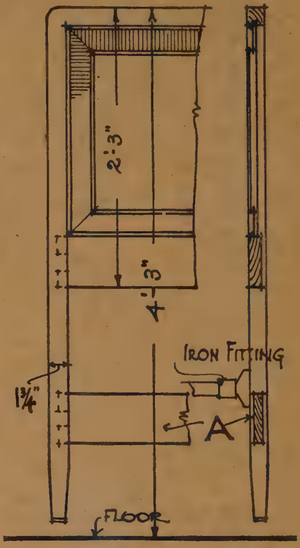


Fig. 30 Fig. 31

Figs. 30 and 31.—Part Elevation and Section of Head of Bedstead

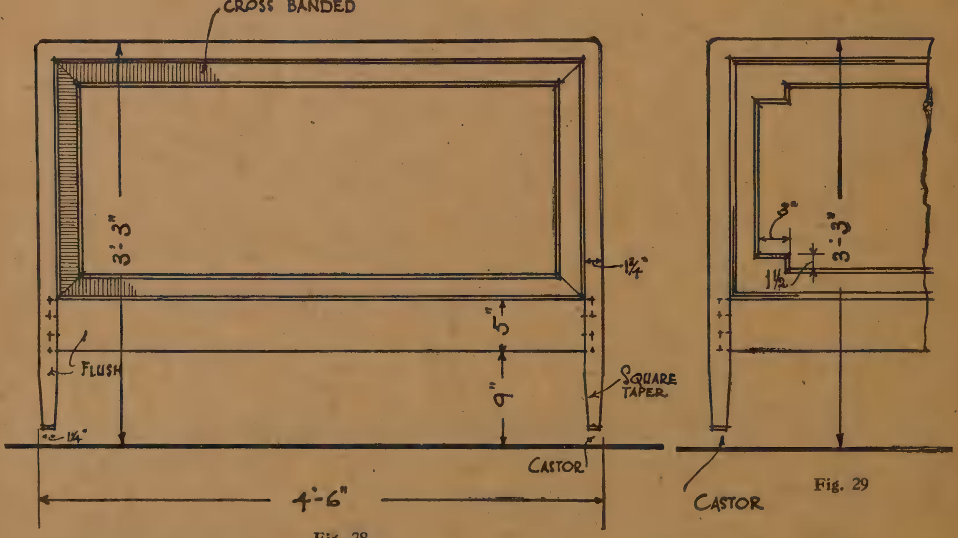


Fig. 28 Fig. 29

Figs. 28 and 29.—Elevation and Part Alternative Elevation of Foot of Double Bedstead

Scale for Figs. 28 to 31

and in the positions shown by dotted lines in Fig. 23, and also indicated in Fig. 24 at O; whilst the third is fixed to the wooden side-piece. On these supporting fillets the shelf, which is about 6 in. or 7 in. wide, will be fixed, and will, if of the proper length, hold the side of the fitment in its correct position.

Next, right across the room, on top of the upright sides, $\frac{1}{8}$ in. less than these in width, and of any convenient light thickness, is fixed a top board as at P in Fig. 24 and Q in Fig. 25. This is further supported on small fillets fixed to the walls at the ends and behind the cupboards, but not in the central bed-recess. Under the front edge of this top, and in order to cover the rods and rings for the sliding curtains, is fixed across each cupboard a shaped arch-piece $\frac{7}{8}$ in. thick, cut out of a width of about 6 in., and fixed $\frac{1}{8}$ in. back from the front edges of the fillets H and J (Fig. 22), which are cut back $\frac{1}{8}$ in. above R (Fig. 24) to allow the picture rail there shown to continue across the whole without interruption. A small moulding may be mitred round the underside of the top as indicated at S in Fig. 25.

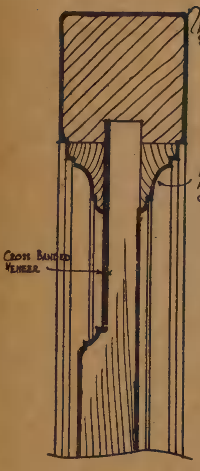


Fig. 32.—Detail Section through Top rail and Panel

Fig. 33.—Alternative Section Showing Bead Planted on Panel

Scale for Figs. 32, 33 and 36

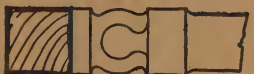


Fig. 34.—Detail Showing Sockets at End of Iron Side Rail

A BEDROOM SUITE

The suite of bedroom furniture about to be described is of a good class of work as regards design and construction. While there are many ways in which it can be varied, the general arrangement is put forward as one suitable for use as a standard on which any variations can be based. It can be carried out in any hardwood and type of finish, but its simple surfaces render it most suitable for material of good selected figure.

The Bedstead.—The bedstead (see Figs. 27 to 31) consists simply of two pieces of panelled framing, united by iron side-rails of **L**-shaped section, with solid ends fitting into sockets which are strongly screwed to the uprights as in Figs. 34 and 35. These fittings can be purchased in sets. The width for a normal double bed would be 4 ft. 6 in., as shown, while for single beds it can be from 2 ft. 6 in. to 3 ft. 3 in., as desired, and in the heights shown the size of the castors to be used should be taken into account.

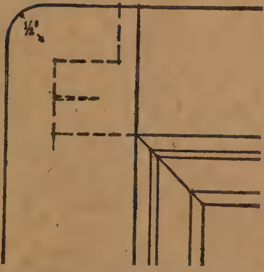


Fig. 36.—Detail at Top Corner of Head or Foot

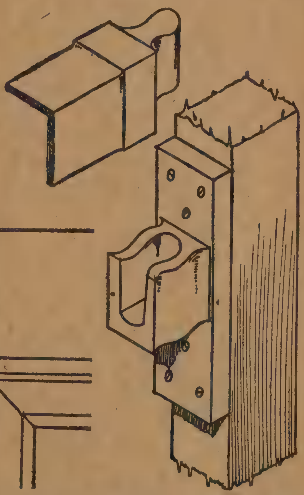


Fig. 35.—Socket and End of Side Rail

The foot consists of two uprights, $1\frac{3}{4}$ in. square, with a top rail of the same size (connected at the corners by means of a secret tenon carefully wedged to ensure

a tight job, and rounded at the angle as in Fig. 36), and a bottom rail 5 in. deep. The legs are square-tapered to $1\frac{1}{4}$ in. next the castors, and the framing is grooved all round for a panel. This latter, it is suggested, should be raised and moulded on the solid, the margins treated with cross-banded veneer (which gives very effective contrasts of grain), and a planted and mitred moulding next the framing, all as shown in Fig. 32. This work can be reduced or modified at discretion. For instance, a planted bead as in Fig. 33 may be substituted for the raised panel in Fig. 32, and if this is done it might very suitably be broken and mitred at the corners on the flat surface of the panel as in Fig. 29.

With the exception of the varied heights and an additional rail A, as in Figs. 30 and 31, the head is similar to the foot; but of course without mouldings at the back. There is also no necessity in this case to make the horizontal rail below the panel the full thickness of the uprights, provided that it is kept flush on the face.

The Washstand.—As illustrated by Figs. 37 to 41, this piece of furniture is of average dimensions, but it can be readily adjusted to any particular requirements. It is of the same wood and finish throughout as the bedstead, and is intended to have a polished-wood top covered with a sheet of clear polished plate glass, slightly rounded at the edges and simply laid in position, as its weight will keep it quite secure. At the back the wall is protected against splashing by means of a washable curtain on a fitting consisting of a rail and two standards, as sold for the purpose and easily adjusted to the exact length required. An oxidised silver finish will be the best for this fitting, although it might be turned in wood, and as it will probably have square bases to the uprights it will be necessary either to keep the back edges of the glass forward to clear these or, preferably, to have the square bases cut away on the inner front angles to a quadrant form, to which the back corners of the sheet of glass can easily be cut with fair exactitude, provided that a template of the exact curves and their distance apart is supplied when the glass is ordered. Alternately the wooden top might be omitted entirely and a slab of selected marble used instead, although this is a more hackneyed idea.

The main framing is best explained by Fig. 42. It consists of legs $1\frac{1}{4}$ in. square, and tapered at the bottom, with horizontal rails of the same thickness, but measuring 1 in. vertically, and two small uprights as at B, all dovetailed and tenoned together in the usual manner. This framing is frail in itself, but gains enormously in strength with the addition of the sides, etc. If increased in size the effect would be somewhat clumsy.

The whole of the back C (Fig. 38) is filled in with three-ply or tongued boarding fixed in slight rebates, and the boarded bottom of the cupboard D can be filled in on top of the four bottom rails, thus avoiding the necessity for rebating them, and also forming a stop for the cupboard doors. The ends should finish about $\frac{5}{8}$ in. thick and be fitted like panels into grooves in the framework. They might be framed up and moulded to match the doors (described later); but elaborated work is rather thrown away in their positions, more especially as in use they will usually be nearly concealed by towels, as shown in Fig. 37.

Fig. 43 shows the moulded edge of the flat wooden top, together with the point at which the plate glass should end. The moulding E need not be housed into the under-side of the top as shown, but it will make the best job if this is done. The top is secured by oak buttons at intervals, working in a continuous groove on the inner face of the four top rails. The top should be finished square at the back, where it would overhang about $\frac{1}{2}$ in. In setting out the standards for the curtain rail it will look best to keep their centres directly over those of the back legs.

With regard to the front, the central divisions at both cupboard and drawer levels are shams introduced in order to make the doors and drawers of a more

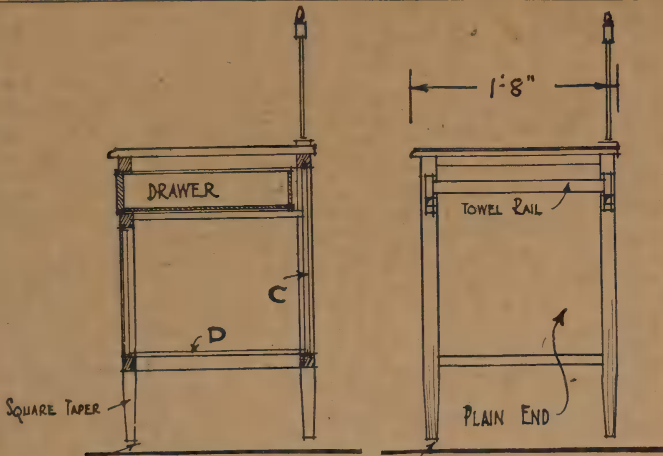


Fig. 38

Fig. 39

Figs. 38 and 39.—Vertical Section and Side Elevation of Washstand

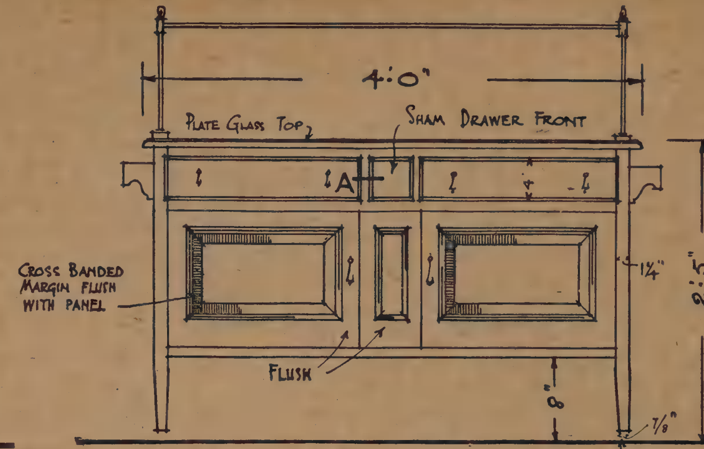


Fig. 40.—Front Elevation of Washstand

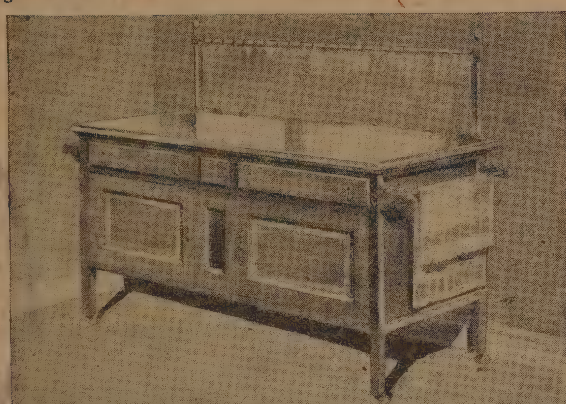


Fig. 37.—The Washstand

Fig. 41.—Part Plans at Cupboard Level and at Drawer Level Respectively

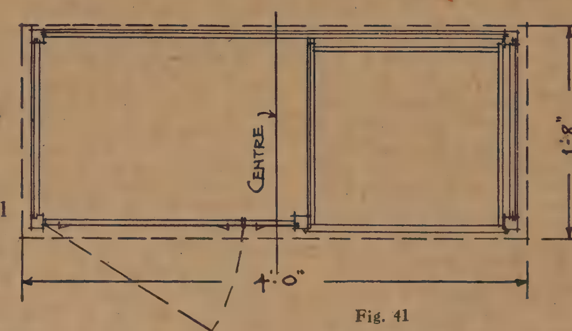


Fig. 41

Scale for Figs. 38 to 41

convenient size, and for this reason although they are not essential they are recommended. The panel between the doors is tongued between the rails and measures 6 in. over all. It is framed up and finished with a planted moulding to match the doors (Fig. 48); but the latter have in addition a band of cross-banding flush with panels and showing as a margin 1 in. wide.

The outer ends of the drawer-spaces are prepared by introducing blocking pieces as at F (Figs. 44 and 45), flush with the inner faces of the front legs, and fixing runners under as shown. This arrangement is repeated on the corresponding

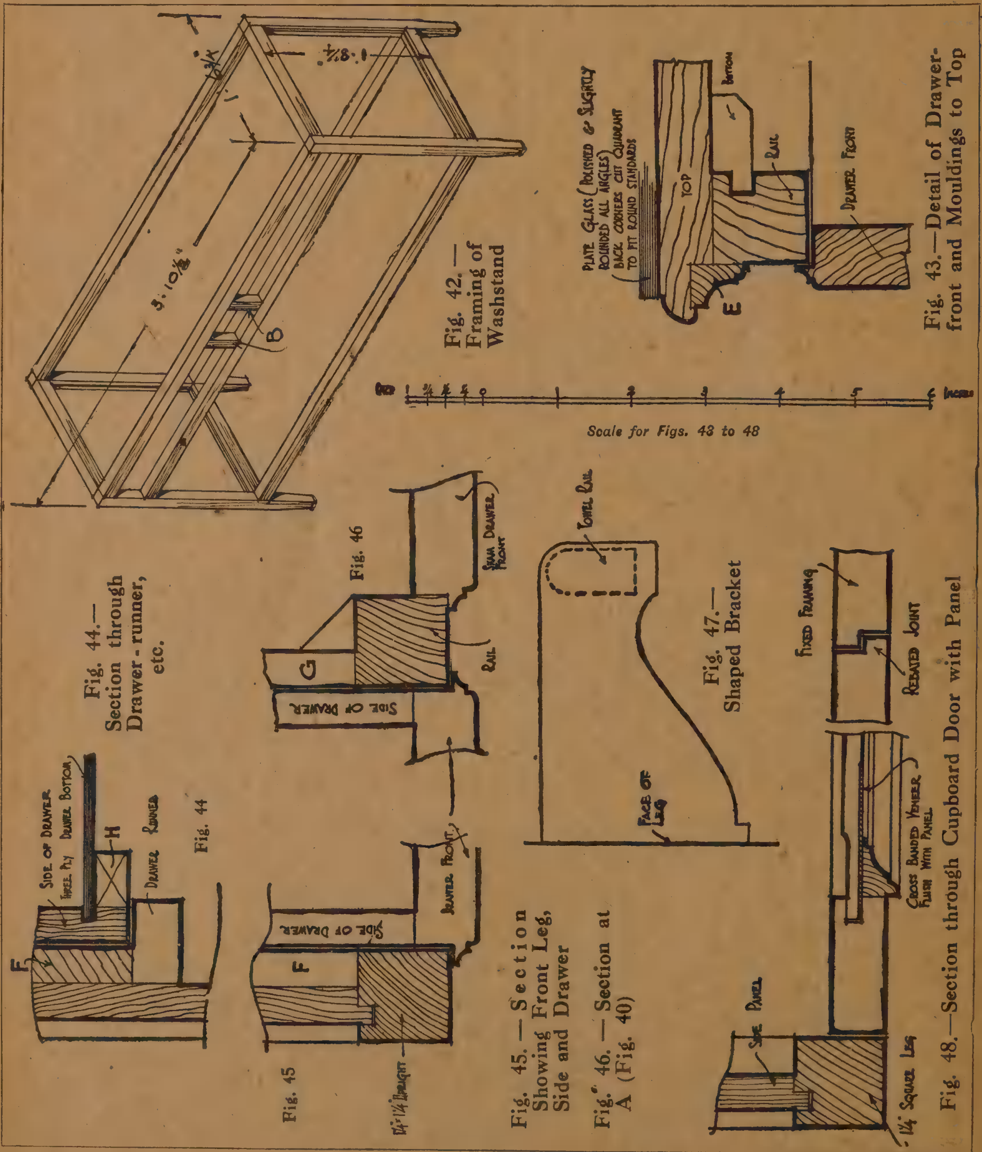


Fig. 42.—Framing of Washstand

Fig. 43.—Detail of Drawer-front and Mouldings to Top

Fig. 44.—Section through Drawer-runner, etc.

Fig. 45.—Section Showing Front Leg, Side and Drawer

Fig. 46.—Section at A (Fig. 40)

Fig. 47.—Shaped Bracket

Fig. 48.—Section through Cupboard Door with Panel

faces of the two short front uprights at A in Fig. 40, the back ends of the runners being supported at the back by uprights run up from the bottom of the cupboard. The blocking pieces in this case are as shown at G in Fig. 46, and if carefully fitted need only be fixed by angle-blocks as indicated.

The drawers themselves are normal with the exception of their fronts, which are moulded and rebated to project slightly as in Figs. 43, 45 and 46. Underneath they should have oak fillets, as at H in Fig. 44, to widen the friction-surface. A similar sham front should be fitted in the centre, but need not necessarily be rebated into position as in Fig. 46. A three-ply division can be fitted immediately below the drawer-runners if desired, as can also a shell midway across the cupboards.

Cut and shaped brackets, as in Fig. 47, should be stub-tenoned in position at the ends, the towel-rails being in wood of the section indicated, unless it is preferred to adopt stout glass tubing or solid glass rods, which would have a novel effect. Drop handles in oxidised silver would give a suitable finishing touch.

The Dressing Table. — In general construction and design the dressing table (Figs. 49 to 53) closely follows the washstand. The main framing is clearly explained by Fig. 54, the back legs running up as shown and slightly tapered to suit square oxidised or moulded wooded caps. The table-top A (Fig. 57) has a moulded edge and is fixed with buttons exactly as before, and should ultimately be finished with a sheet of plate glass. This can be rectangular in shape, as the standards have a skirting B (Figs. 50 and 58), flush with their front faces tenoned into them, and housed into the table-top. This skirting has a moulded capping as in Fig. 58, mitred and returned to the standard face at its ends.

As the ends are more exposed than in the case of the washstand they should have panels raised, cross-banded and moulded as in Figs. 51 and 55, fixed in grooves in the framing. The back and bottom can be filled in with three-ply.

The drawers should have oak fillets to increase their bearing-surface as at C in Fig. 56, and D in the same figure shows a rebated form of hardwood runner fixed across the ends. If adopted, this runner will obviate the necessity for boxing out the inner face of the ends close up to the drawers as would usually be done. A double version of this runner will be necessary at E in Fig. 50, and it should be tenoned into the front rail and the back upright at F in Fig. 54.

Fig. 49.—The Dressing Table

While a long oval mirror would look well, this would be rather an heroic task for the amateur, who will find it quite a delicate piece of work to produce the rectangular frame shown, which, it is advised, should be made to the section in Fig. 59, with a very small bead worked on the solid next the glass. It is mitred at the angles, which are slightly rounded

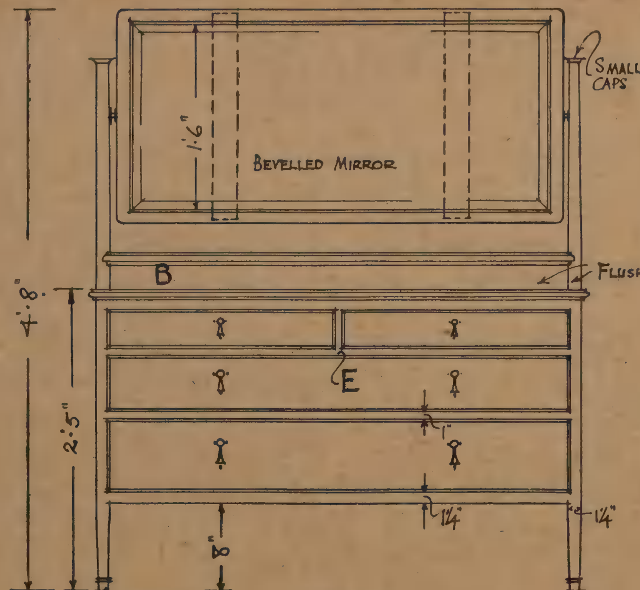


Fig. 50

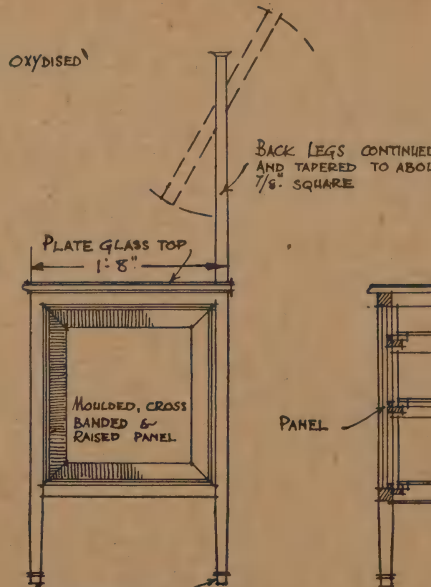


Fig. 51

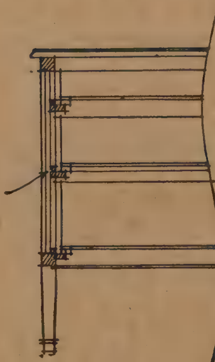


Fig. 52

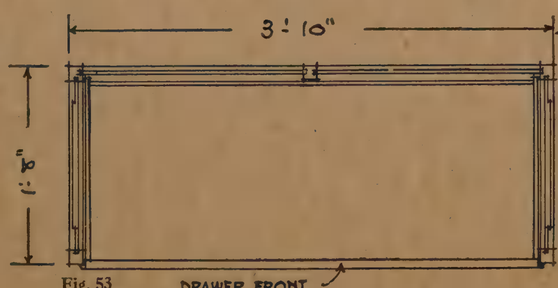


Fig. 53

Figs. 50 to 53.—Front Elevation, Side Elevation, Part Longitudinal Section and Horizontal Section at Drawer-level of Dressing Table

Scale for Figs. 50 to 53

as in Fig. 50. They should be strengthened either with oak slips or tongues put in on the edges or small brass angles screwed on at the back. The bevelled mirror will need very precise adjustment in the frame, by means of small strips of wood between its edges and the rebates. It should be fixed with fillets as at G, and a thin back let into the smaller rebate as at H. The whole frame will be considerably stiffened by the addition of a couple of vertical ledges as dotted in Fig. 50, screwed on the back and rounded on all exposed angles.

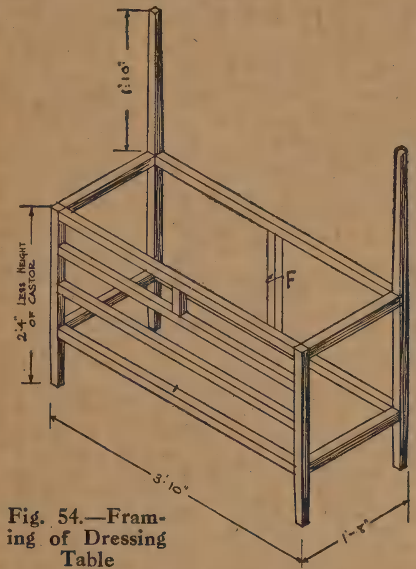


Fig. 54.—Framing of Dressing Table

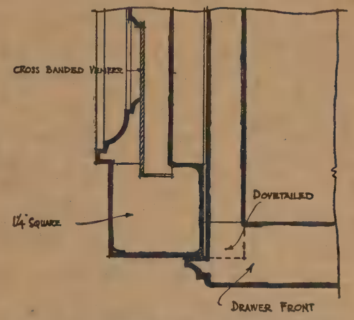


Fig. 55.—Section Showing Front Leg, etc., of Dressing Table

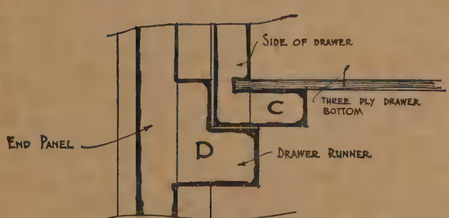


Fig. 56.—Section Showing Drawer-runner, etc.

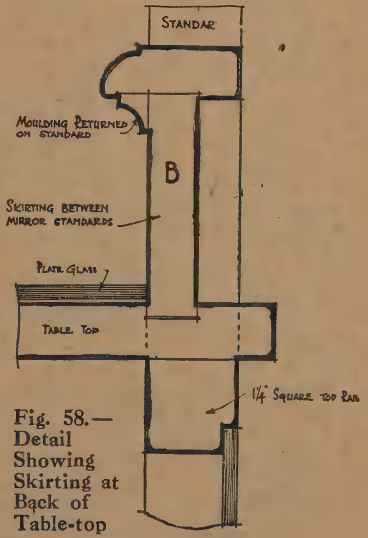


Fig. 58.—Detail Showing Skirting at Back of Table-top

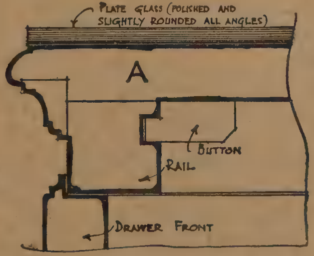


Fig. 57.—Section through Table-top, etc.

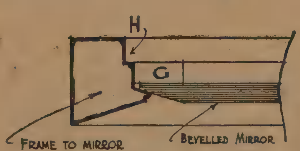


Fig. 59.—Detail of Mirror Frame

A SIMPLE DINING TABLE

The simple dining table shown by Figs. 60 to 62 is comparatively easy to make. Success depends largely on the restrained design, absence of ornate details and the use of good quality oak.

The main dimensions are 5 ft. long over all, 3 ft. wide and 2 ft. 6 in. high. The length could be varied according to the size of the room, but it is advisable that the width should be kept to the size given, as if made less it will not be comfortable. The legs should be prepared first, squared up to the required size ($3\frac{1}{2}$ in. or 3 in. square), the rails being framed to the legs with mortise-and-tenon

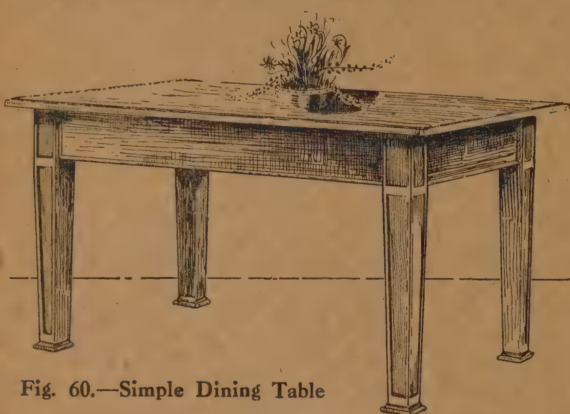


Fig. 60.—Simple Dining Table

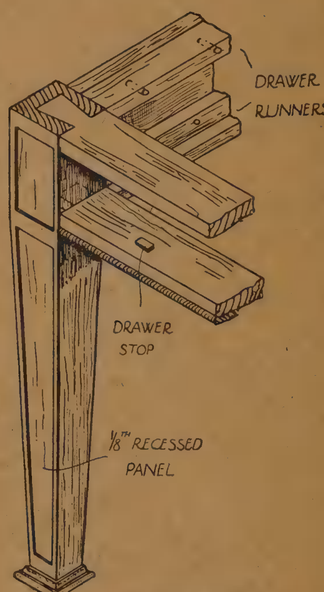


Fig. 63.—Framing of Table

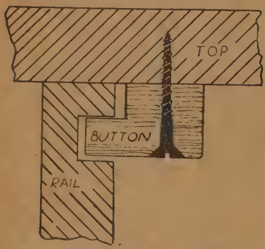


Fig. 64.—Detail Showing How Top is Attached to Rails

Fig. 65.—Detail of Table Foot

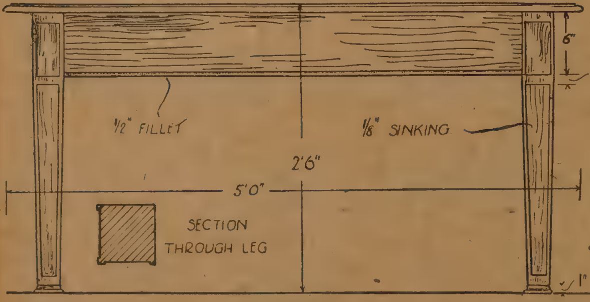


Fig. 61

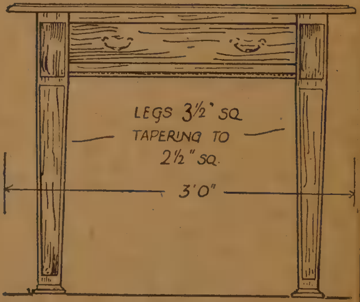


Fig. 62

Figs. 61 and 62.—Elevations of Simple Dining Table

joints in the usual way. The drawer rails, details of which are shown in Fig. 63, are screwed to the rails, the "kicker" and runner preventing the drawer from "kicking," so often seen in cheap furniture because of bad fitting of the kicker and runner. The drawer can be divided up by partitions to take the various forms of cutlery.

To make a really strong job it is advisable to draw-bore the tenons: that is, bore with a $\frac{3}{8}$-in. dowel bit through the leg at right angles to and through the mortise joint. The tenon is bored $\frac{1}{32}$ in. behind, so that in gluing up the dowel will force its way through the three holes, thus drawing the shoulder of the rail close to the leg.

When the framing is complete the legs should be taken apart and stop-tapered, allowing 1 in. for the moulded foot. A simpler method is to carry the taper right through, working the foot separately, then screwing it on; but the former will be found the better way. The four legs are now ready for the recessing, which, after being roughed out, is finished with the router or "old-woman's tooth." It should be borne in mind that only the two outside faces of the leg need recessing. The feet should now be moulded, a suitable moulding being shown by Fig. 65, and after careful cleaning the framework is then ready for gluing-up. Care should be taken to warm all the joints, and to see that the bed or ground on which the gluing is to be done is true, otherwise creaking will result, and also the top will be in winding.

The top can now be prepared, and if cramps are available dowelled joints should be used; but if not, ordinary rubbed joints will be found very effective if the joints are well warmed. After levelling, the thumb moulding can be worked with a rebate plane.

Buttons are by far the best method of fixing a large top to a framing, owing to the latitude they allow for expansion and contraction, although they hold the top to the framing without any vertical play whatever. They are made as shown in Fig. 64, 1 in. long, $\frac{3}{4}$ in. wide by $\frac{3}{4}$ in. thick, with a small lip of $\frac{3}{8}$ in. to enter the rail socket; after marking the sockets in the rail, the slots cut, they are screwed on the underneath of the top. The whole is now ready for final cleaning up, colouring, filling and polishing.

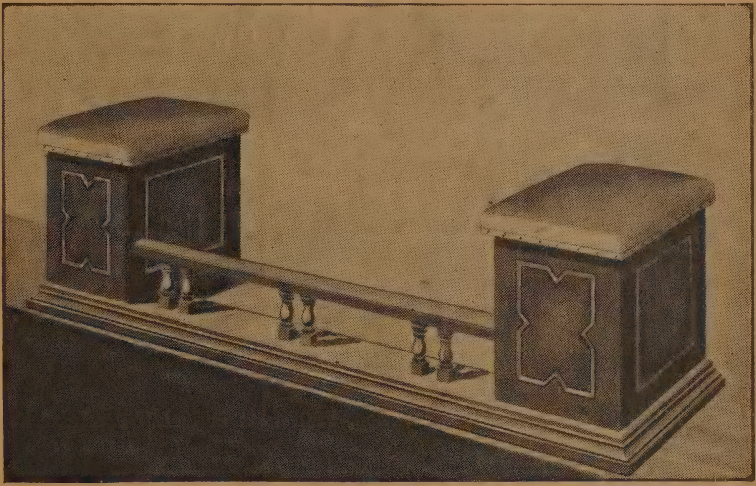


Fig. 66.—Jacobean-style Fender Seat or Seater Curb

A FENDER SEAT OR SEATER CURB IN JACOBEAN STYLE

The fender shown in Figs. 66 to 69 is intended to be made of oak. The first consideration will be the base, the arrangement of which is shown by Fig. 70. In section this is 3 in. by $1\frac{1}{2}$ in., and a moulding similar to that shown in Fig. 71 should be worked along the front edge. Probably the easiest way to obtain this moulding will be to cut a rebate and

glue in a strip of machine-prepared moulding of suitable section (see dotted lines in Fig. 71). The ends of the base are mitre-tenoned to the front, while additional pieces A are tenoned in to form the base for the box seats.

able moulding. The sectional plan included in Fig. 68 shows the front corner joint between the front and sides, and it will be noted that the front stiles of the side panels will need to be narrower than the back stiles. The $\frac{1}{2}$-in. bottom is

Fig. 67

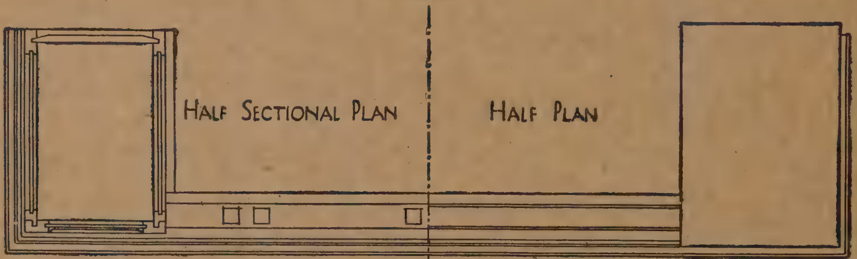


Fig. 68

Figs. 67 and 68.—Front Elevation, Half Plan and Half Sectional Plan of Fender Seat

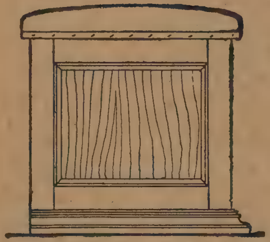


Fig. 69.—End Elevation of Fender Seat

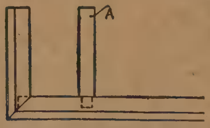


Fig. 70.— Half Plan of Base Framework

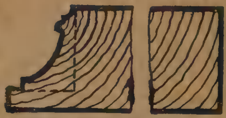


Fig. 71.—Section through Base

Scale for Figs. 67 to 69

Having completed the base the box seats will be the next part of the work. The fronts and sides are straightforward pieces of framing, $\frac{5}{8}$ in. thick with $\frac{3}{8}$-in. panels, the Jacobean effect being secured by gluing in the necessary triangular-shaped pieces and mitreing round a suit-

secured to the sides by two dovetails both at the front and at the rear, while the back is simply bevelled off and grooved into the sides as shown. The padded seat projects 1 in. all round, and may either be a solid piece or it may be framed together, upholstered and hinged as

shown in Fig. 67. The interior of the boxes may be used either as slipper boxes or coal containers according to requirements.

All that remains now to be done is to prepare the moulded rail B, which is $1\frac{1}{2}$ in. by 1 in., the top edge being rounded, and then the turned columns which are 1 in. square. These may be either of the pattern shown or may be spiral turned, although it must be confessed that the "barley-sugar twist" in furniture is becoming rather hackneyed. The columns are stub-tenoned between the rail and the base, and the rail stub-tenoned to the boxes. The boxes are screwed to the base from the inside.

When the whole has been satisfactorily assembled it may be stained down to the requisite colour, in accordance with instructions given on p. 194 of this volume.

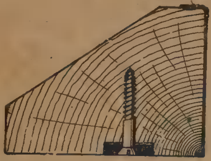


Fig. 73.—Section Through Fender Curb

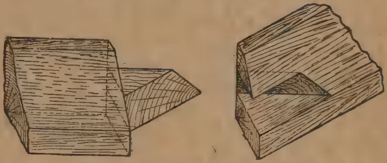


Fig. 74.—Detail of Joint in Curb

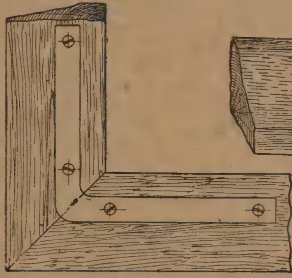


Fig. 75.—Corner with Strengthening Piece

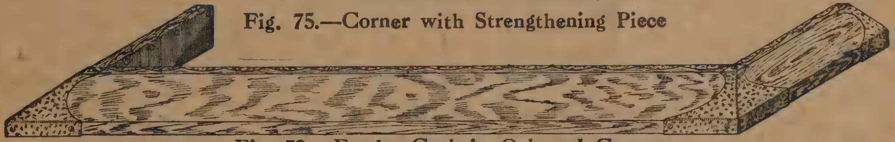


Fig. 72.—Fender Curb in Oak and Copper

AN OAK AND COPPER FENDER CURB

The fender curb shown by Fig. 72 should be made of thoroughly seasoned, bone-dry English oak, and the dimensions should be made to suit the length and width of the hearth for which it is intended, usually about 4 ft. 6 in. by 11 in.

The section of timber used is 4 in. wide by 3 in. deep, and it will save a lot of work if it is ordered to be cut as shown in Fig. 73, so as to show the best figure on the front inclined face, which should be parallel to the medullary rays; an allowance of $\frac{1}{8}$ in. extra should be allowed for cleaning up. When the oak is received it should be kept for two or three weeks in the same room in which it will be used before being worked.

The mitre-mortise joints at the corners shown by Fig. 74 should be made a good fit, and the use of glue is to be avoided. Two No. 12 screws should be used in each joint, taking care that in driving the screws they are inclined towards the joint, so as to pull it together. Further, to strengthen the joints, a 1-in. by $\frac{1}{4}$-in. iron L-piece is housed flush with the under-side of the curb at both corners (see Figs. 73 and 75), using four No. 12 screws in each as shown, care being taken that they do not foul the screws already in the joints. Both joints can now be cleaned up level, and the whole finished with fine glasspaper. It should be rubbed over with raw linseed oil to bring out the figure, after which it can be stained a golden brown, and finished by french- or wax-polishing.

The copper corner plates should be made from No. 20 gauge to the shape shown, or any other to suit individual taste. A stiff paper pattern should be cut and bent to fit the corner, and it will be necessary to cut out a small gusset at

the top and bottom to fit it properly. The pattern can then be laid on the copper and marked off, two being required. After being cut out the plates should be hammered all over on the face side with the ball pene of a small hammer, which will give a pleasing effect, at the same time masking any scratches or blemishes which may otherwise show.

The corner plates, after being bent to shape, will have to be soldered at the joints, where the small gussets have been cut out. The joint should be quite close, and should be soldered from the back, the holes being drilled in for the small brass snap-head screws for securing them. They can then be cleaned up and polished with a liquid or paste polish, then lacquered and put on one side to thoroughly dry and harden, the end plates being cleaned and lacquered in the same way.

The inside of the curb is lined with copper sheet, No. 20 gauge thick, hammered perfectly flat and thoroughly cleaned up with fine emery-cloth before being finally polished. The top edge of the copper lining is cut to the pattern shown, and then neatly bent over at right angles. This can best be done by clamping the copper sheet between two pieces of preferably hardwood, with the edge to be bent projecting above. The edge can then be carefully bent over with a wood mallet or leather-faced hammer. It will be found better for working if the front lining is in two pieces, the joint, of course, being in the centre. The lining should be secured to the curb with small brass snap-headed screws placed not more then $2\frac{1}{2}$ in. apart.

A LABOUR-SAVING KITCHEN TABLE

The table is the most used article of furniture in the kitchen, and everything that is required on it has to be carried to it from cupboards or dresser. Why should this be when, by adding suitable drawers and cupboards, the majority of articles used on it may be kept under it and conveniently arranged? A suggestion for fitting up an ordinary kitchen table 4 ft. by 2 ft. 9 in. is shown by Fig. 76. The fittings have been designed so that an amateur may attempt it with success. Figs. 77 to 79 show the construction.

The most business-like method of dealing with the work is to make a scale drawing on the lines shown by Figs. 78 and 79, and then work out the materials.

Start the work by turning the table upside down, and fit the four rails R^1, R^2 as in Fig. 80. These are made from ordinary $2\frac{1}{4}$-in. by $1\frac{1}{4}$-in. batten, planed to 2 in. by 1 in., or if the material will allow, $2\frac{1}{8}$ in. by $1\frac{1}{8}$ in. The lengths should be cut off 2 in. longer than the distance between the legs. Each end should be marked out as shown at A (Fig. 82). These ends should be sawn down with a tenon saw, giving the dovetail a very slight taper. Give each end a distinguishing mark, then place them one by one in their respective places, and carefully mark the shape of the dovetail as shown at B. Next saw the sockets as far as possible with the tenon saw, and then remove the waste with suitable chisels. The legs will now be as shown at C, and the rails, when lightly tapped in position, will make a complete frame.

The uprights (Fig. 84) have now to be fitted. Each of them is cut to the shape shown and then let into the bottom and top rails. The distance between the leg L^1 (Fig. 80) and the upright B should be about 1 ft. 4 in. in a table 4 ft. long. The next stage, after gluing and fixing all joints in the framing, is to fill in the end at L^1 and the back with $\frac{1}{2}$-in. thick matchboarding. The easiest way of doing this is to nail the matching from the inside to the rails, and in most tables there is sufficient space underneath the top drawers to allow of this. An alternative method is to use a thin panel, either of three-ply or compressed-fibre beaver board, which may be obtained from a builder or timber merchant, and tack the panel against fillets, which should be nailed on the inner surface of the rails and legs as shown in Fig. 81.

Partition.—A partition should now be made from 2-in. by 1-in. wood, joined at the corners with the halving joint, the framing being covered on one side with

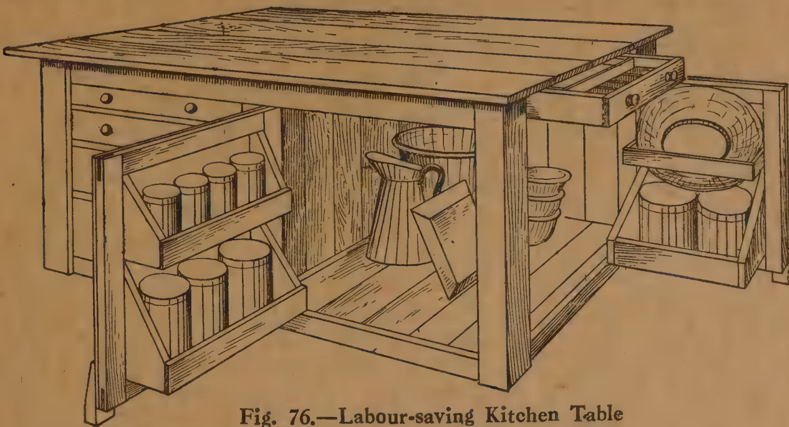


Fig. 76.—Labour-saving Kitchen Table

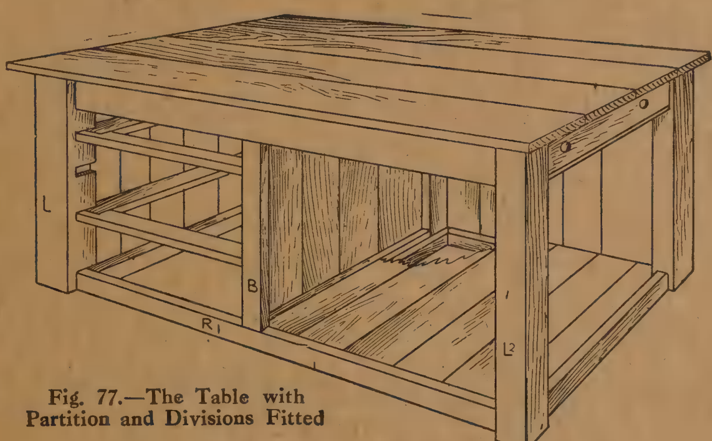
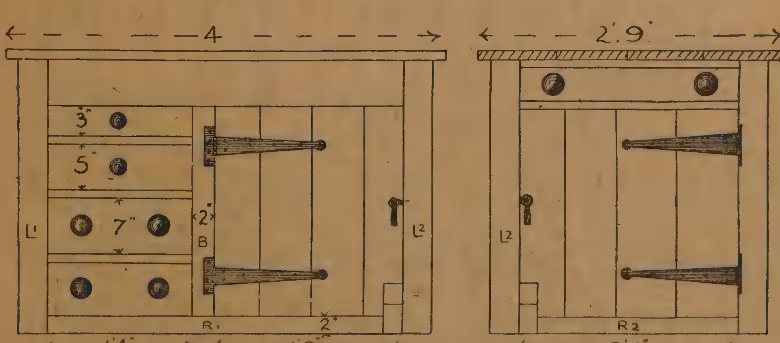


Fig. 77.—The Table with Partition and Divisions Fitted



Figs. 78 and 79.—Two Elevations of the Table

matching or panelling (see Fig. 83). The measurements of this frame should be taken from the inside of B (Fig. 80) to the back as to width, and from the floor to the top as high as possible; probably 1 in. above the level of the bottom edge of top rail. This partition should now be nailed or screwed in place, with the boarded surface on the drawer side and flush with the inner side surface of B, as shown in Fig. 77.

Divisions.—Now make three frames, as shown in the lower part of Fig. 83, to fit in between L^1 and B to provide the divisions for the drawers. These should be made from the same size batten as previously used, long enough to fit against the back and be flush with the front surface of B. The lining inside the partitioned end against L^1 will not be flush with the inner side surface of the leg; but the full width of the space from boarding to boarding must be measured. In order to have a plain length of wood for the front of the dividing frames it will be necessary to make the front joint of the frames as shown by Fig. 86, and to fit these frames in position it will also be necessary to cut a groove for each frame on the inner surface of the leg as shown in Fig. 77. The exact distance between the boarding and the inner surface of L^1 must be measured, and if more than $\frac{1}{2}$ in., the difference must be cut away from the frame as indicated. It is not advisable to weaken the leg by cutting grooves deeper than $\frac{1}{2}$ in.

The approximate distances for the position of the dividing frames is 3 in., 5 in., and 7 in. for the top three, the bottom space being dependent on the height of the table.

It is important that the position of all these dividing frames should be accurately marked off on the inner sides of the position; the running of the drawers depends on this almost entirely, and nothing is more annoying than a badly-fitted drawer. There is no reason why the drawers should not run easily, provided that the dividing frames are all parallel to one another and at right angles to the sides.

The Drawers.—The form of construction for the drawers is not ideal, but it is the best in the circumstances and within the capabilities of the amateur. The drawers are not difficult to make; two methods are shown. A particularly simple way which avoids dovetailing is shown by Fig. 89, and the ordinary dovetailed and ploughed construction by Fig. 90.

For both methods, the first thing to do is to fit the drawer opening with a length of 1-in. or $1\frac{1}{4}$-in. thick wood, making an exact fit and marking the position of the top in each case. In the simple form, the sides should be $\frac{3}{4}$ in. thick, the thickness of the bottom less in width than the front, and the exact length of the inside less the thickness of the front. A rebate should be sawn out of each end of the front piece $\frac{3}{4}$ in. each way, as shown at A, and the sides should be nailed to it. The rebate should be continued along the base, and then the end length and base nailed on as shown at B. It is of the greatest importance that the angles should be right angles, and a try-square should be used continually when fitting the parts together. The dovetailed drawer should have the sides the same width as the front, and just a $\frac{1}{4}$ in. shorter than the length of the dividing frame.

The ends of the drawer front should be marked out as dovetail pins as at C (Fig. 90), and placed on the side lengths in turn so that the sockets may be marked off and cut out as shown at D and E. Many consider that the work of making a dovetail drawer is beyond the powers of the amateur, but if the method suggested is followed the work will be found to be quite straightforward.

The width of the end of the drawer should be $\frac{5}{8}$ in. narrower than the sides, in order to allow for the bottom piece. This is fitted in grooves in the sides $\frac{3}{8}$ in. up and $\frac{1}{4}$ in. wide and deep (see F), and the groove may be made with saw and chisel, or with a $\frac{1}{4}$-in. chisel fitted in a block (see Fig. 87) if a plough is not available. The illustrations should make all these points quite clear.

All the drawers should be made in the the same way, and when glued or nailed up

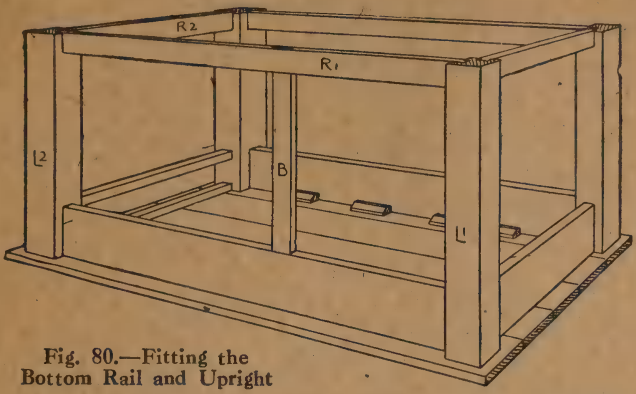


Fig. 80.—Fitting the Bottom Rail and Upright

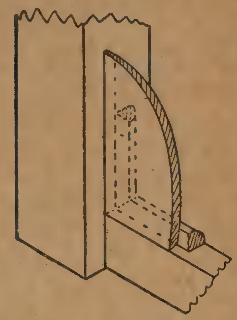


Fig. 81.—Another Method of Filling in Back and End

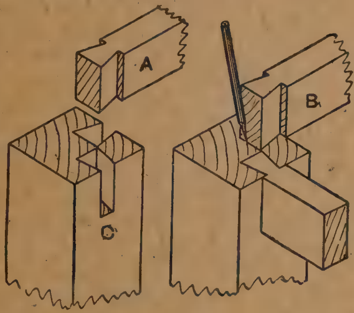


Fig. 82.—Dovetail Joint for Rail

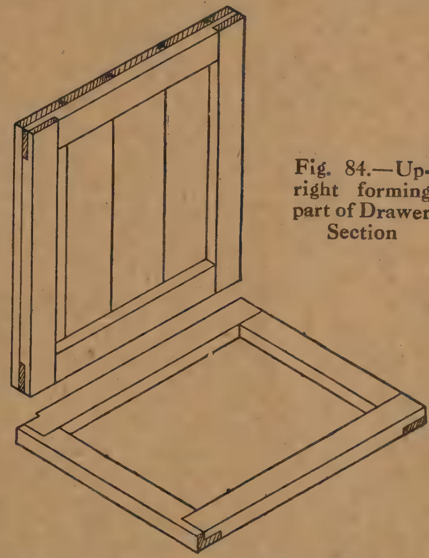


Fig. 84.—Upright forming part of Drawer Section

Fig. 84

Fig. 83.—Partition and Dividing Frame

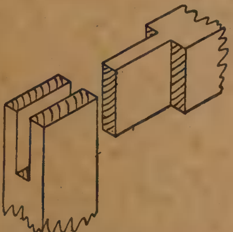


Fig. 85.—Mortise-and-tenon Joint for Door Frames

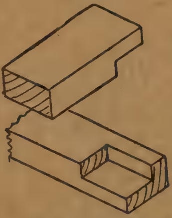


Fig. 86.—Joint for Front of Dividing Frame

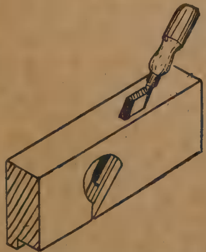


Fig. 87.—Plough for Making Grooves

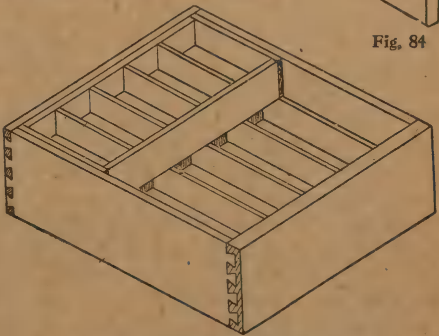


Fig. 88.—Drawer Divided Up

should be cleaned off with a smoothing plane to get an accurate fit, and then fitted with handle or knobs.

The most difficult part of the work and certainly the portion taking the most time, has now been completed.

Completion.—The next stage is to fit a bottom to the remaining space as shown in Fig. 77. The boards should be nailed on to fillets of $1\frac{1}{2}$-in. by 1-in. wood nailed on to the inside of the framing.

The two doors should be framed up preferably with the mortise-and-tenon joint (Fig. 85), but the ordinary halving joint used for the partition may be used instead. The frames should be covered with matchboarding or panelling and attached to the legs with cross-garnet hinges, these being much more suitable for a simple door framing than butt hinges.

The brackets and supports for the shelves should be cut from $\frac{3}{4}$-in. thick wood, and the arrangements shown are suggestive and need not be strictly adhered to, as other methods of utilising the space may be found more convenient.

To prevent the weight of the shelves and their contents pulling the door out of shape, a projection should be screwed to the outside of the door. Either a roller or ball caster should be fitted; or a "dome" will answer very well. If the table is likely to be moved about, it will also be advisable to fit the legs with casters.

The new woodwork should be stained and varnished as preferable to paint, although a hard-drying enamel paint would look very well. Either button catches or handles should be fitted to the doors to complete the work.

The internal fittings of the drawers should not be neglected, as a considerable amount of time is saved by having sliding shelves and partitions in the drawers as shown by Fig. 88.

Thin wood about $\frac{1}{4}$ in. or $\frac{3}{8}$ in. thick should be used. In the suggestion given by Fig. 88, the lower portion of the drawer is divided off into compartments, the height being about half-way up the drawer. On the top of these divisions a partitioned shelf runs. This is made to the whole width of the drawer, but only half the length. Other arrangements will probably suggest themselves, the main thing being to fit everything in a place where it can easily be reached.

In dealing with tables smaller than 4 ft., it will be as well to reduce the drawers to a width of 12 in., and any further reduction should be made to the cupboard.

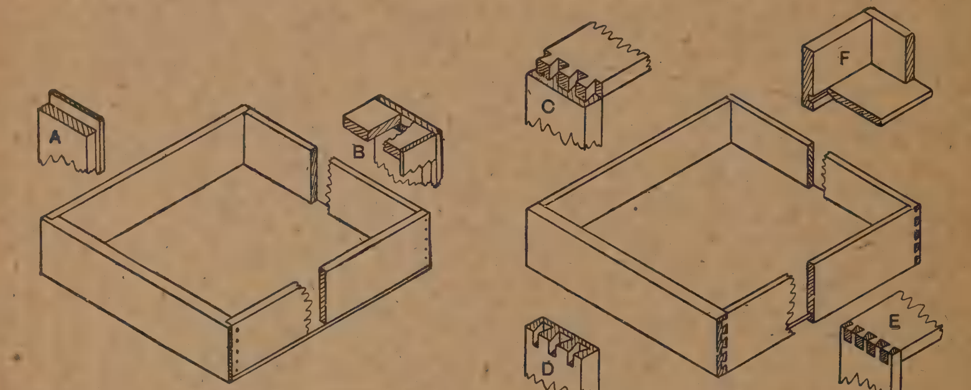


Fig. 89 Fig. 90

Figs. 89 and 90.—Drawer Without and With Dovetail Joints

Wood-polishers' Stains

In general, two kinds of stains are used by the french-polisher, water stains and spirit stains, both of which can be obtained ready made. Many of them can be had in powdered form, requiring only the addition of water or of methylated spirit respectively.

Aniline colours, soluble in either water or spirit, are extensively used, but they do not stand when subjected to strong sunlight. Almost any shade can be got, but yellow, bismarck brown (a deep rich red, suitable for mahogany), and black (called nigrosine) are those in most general demand. The yellow and black dyes must be specified for solution in water or in spirit, but bismarck brown is soluble in either water or spirit.

A good powder stain for dissolving in methylated spirit is "spirit mahogany"; this is strong in effect, requiring but a small quantity to make a powerful stain, which can be toned down by adding more spirit. For mahogany, bismarck brown or spirit mahogany will suffice; for rosewood, bismarck brown and a little black are mixed together. Walnut stain requires bismarck brown, black and yellow in varying proportions, according to the tone desired; while for ebonising (or imitating ebony) nigrosine (black) is used, with just a little aniline blue to check the greyness. The combinations of colour apply, of course, to both water and spirit stains. For the mixing of more permanent spirit stains there are gas and vegetable blacks, besides the spirit mahogany already mentioned, and turmeric for yellow, with dragon's blood for a lighter shade of red than that obtainable from spirit mahogany.

Water Stains.—Among the water stains, the following are in most common use: For mahogany, bismarck brown, venetian red (a dry powder suitable for cheap work only), and burnt sienna (ground in water); for walnut, vandyke brown (ground in water), umber (a dry powder), and also a mixture of bismarck brown and aniline black; for rosewood, logwood extract (which is preferable to the chips, as these require boiling in order to obtain the colour from them), and a mixture of bismarck brown and aniline black; for ebony, water-soluble aniline black; for water stain for general darkening-down, bichromate of potash (called chroma), which is a chemical in reddish-coloured crystals easily soluble in water.

Obtaining Evenness of Tint.—For working up inferior woods, such as american whitewood, etc., to represent woods of superior quality, the staining must show depth of colour, and in order to secure this and to obtain evenness of colour it is better to give the work two or more coats of weak stain rather than one strong coat. Spirit stains give greater density of colour than water stains, and have an additional advantage in not raising the grain of the wood to any appreciable extent. Two or three applications of water stain to a softwood are certain to raise the grain considerably,

and the wood needs to be lightly glass-papered after each coat is dry, removing no more stain than can be helped. Let each coat dry before applying the next.

Some portions of certain hardwoods are of lighter tint than other portions, and will need to be darkened-down to match their surroundings; unless the difference in colour is very marked, bichromate of potash solution can be used for toning down. The action of the bichromate is not direct, the stain being of a deep orange colour when strong, but darkening as it dries. When the desired colour is observed, wipe over the wood with raw linseed oil, which checks the action of the potash, or rather the action of light on the stain. The bichromate takes some time to dissolve, and should therefore be kept ready made up.

Cleaning Prints and Engravings

PRINTS from engraved plates are frequently found suffering from dirt marks, grease stains and damp discolouration. Light rubbing with the softest india-rubber or with stale bread will do much to remove dirt, but to remove grease stains it will be necessary to put the engraving between several folds of clean blotting-paper, and pass a hot iron over it. Continually change the paper and repeat the ironing. Several applications of rectified benzine are also effective in removing grease.

Damp and age stains may be removed in the following manner:—Put the engraving in a flat dish—a sheet of glass with wooden sides dressed with paraffin wax will answer—and pour over it a mixture of equal parts of benzoin and a concentrated solution of chloride of lime in water. Very slight friction with a camel-hair brush may be applied to a particularly obstinate mark. Let the engraving remain till the stains disappear; pour off the bleaching liquid and then with cold water, well wash the engraving as it lies in the dish. On no account attempt to take it out or it will be torn and spoilt. After a dozen or so changes of water, let it soak for an hour in fresh water, and afterwards tip up the dish and let the engraving dry where it is.

Metal Collars of Glassware, etc.

THE following information applies to the rims and collars to be found upon glassware and china, as, for example, lamp reservoirs, sugar-castors, pepper-boxes, salad-bowls, etc., etc. For removing the collars, etc., if it is wished to use them again, allow them to stand for some time in dilute hydrochloric acid, which will dissolve out the plaster-of-paris; but if the collars, etc., are not required, place them in strong nitric acid, which will dissolve the brass. If the glassware is to be destroyed, file a number of marks just above the collars, heat a piece of glass rod or thick iron wire in the blowpipe flame, and place it on the file marks. Often a crack will go right round at once; if not, the crack can usually be obtained after two or three heatings in this way. Another method is to hold the collar in a vice to the jaws of which two pieces of thin sheet lead have been fitted, and then with both hands to take hold of the glass vessel and carefully rotate it; if the collar does not move, soak in water and try again.

The rims and collars are fixed with cement as a rule, one of the best being plaster-of-paris wetted with a saturated solution of alum in water, worked up briskly and applied immediately. Powdered alum alone may be used as a cement; fill the rim, etc., with the alum, place on a hot stove, etc., until the alum softens, press the glassware into the rim, and remove to a cool place, where it should be allowed to set without disturbance.

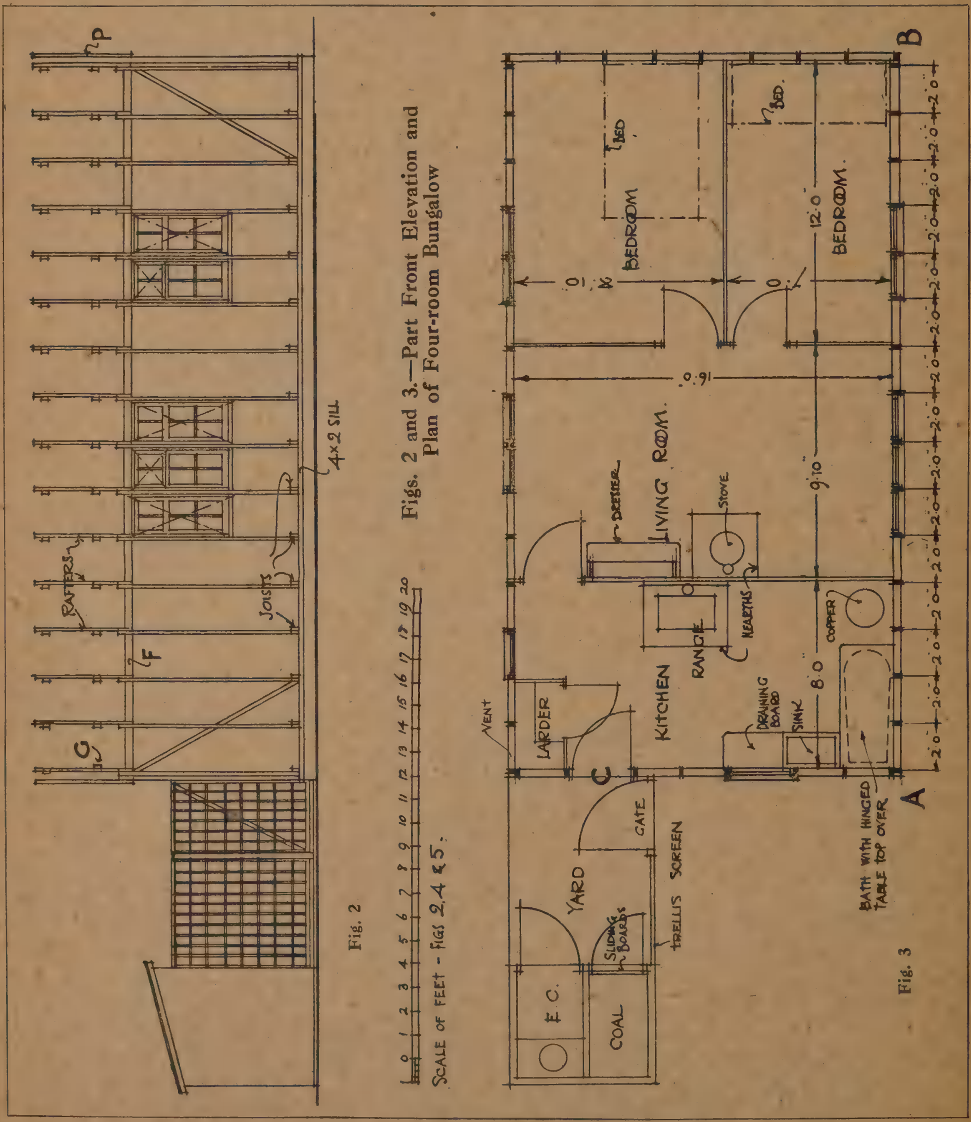
Building a Four-room Wooden Bungalow

It is wise for the reader to realise at the start that the task of building a small bungalow should not be too lightly embarked upon, as even the simplest structure involves not only a considerable amount of labour and a large supply of materials and fittings, but also the expenditure of considerable time. Costs should be gone into before starting to build.

Formalities to be Observed.—There are several formalities to be observed in a matter of this kind. To begin with, the land should be properly and legally held, either freehold or for a definite term of years, otherwise the builder may find himself the unfortunate owner of a dwelling on land claimed by someone else. Then there is the question of

Fig. 1.—The Bungalow Complete

complying with the requirements of the surveyor to the local authority—a very important point. It is necessary as a preliminary step to see the surveyor and ascertain his views. He will almost certainly require plans and sections of the proposed structure and particulars of its site, distance from other buildings, means of water supply, and any proposed arrangements for drainage. He should be notified when it is proposed to start work, and his certificate of satisfactory completion is necessary before the premises can be legally occupied. His advice will probably be of great use, and his stipulations—even if in the opinion of the prospective builder they seem onerous—in the best interests of the builder.



Figs. 2 and 3.—Part Front Elevation and Plan of Four-room Bungalow

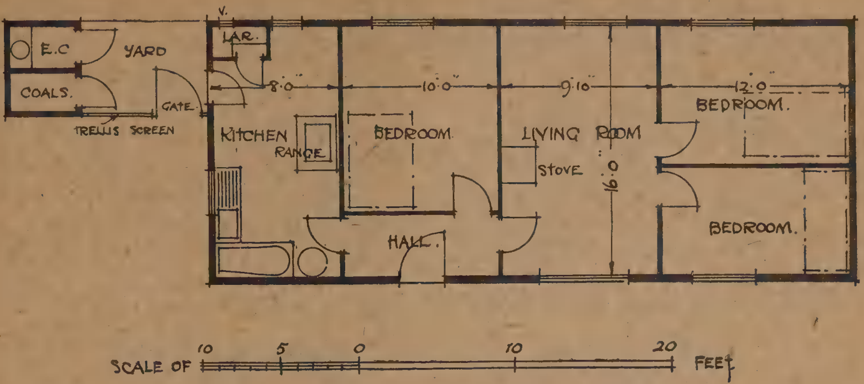


Fig. 4.—Alternative and Larger Plan of Bungalow

Water.—A supply of pure water convenient to the site will be essential. If a main is near it will be easy to get it laid on to the kitchen by arrangement with the company, or a stand-pipe provided. Otherwise water must be obtained from a stream, spring, well, or, if none of these alternatives offers, it must be collected by means of eaves-gutters connected to a storage tank whence it can be pumped to the kitchen. Of course, the usual precautions of filtering and boiling water obtained from unconventional sources should be observed.

Drainage.—This is another big question. Should a sewer be available, proper drains should be put in by a qualified man, whose services would also be required if a cesspool were constructed. The simplest course in a rural area is to install a simple earth-closet (particulars of which are given later), and to take the waste from the sink and bath to a pit which should be frequently cleaned and deodorised. In suitable ground much of the liquid will soak away, while in some cases it may be possible to let it filter through a trench filled with coke breeze or gravel to a ditch or other water-course. It may be insisted on by the authorities that a small cesspool be provided; this would simply be a brick chamber with a trapped drain from the house.

On a dry soil the rainwater, if not required for use, can be allowed to drip to the ground, but on clay it will be necessary to provide two barrels as water butts, and to fit gutters and down-pipes leading to these.

The Site.—The site is another important matter and should be considered with special reference to the points of drainage facilities, etc., outlined above. It should be on dry ground, not in a hollow, not too much overshadowed by trees, not on the shady side of a hill, and not in too exposed a position.

Such a bungalow as shown by Figs. 1, 2 and 3, and about to be described, would be passed in most districts, provided that it is not close to other buildings. The usual procedure of a local authority is to treat such a case as a temporary building and to issue a licence for probably five years; this will be renewed for further periods if the structure is found to be in a sound condition at the expiry of the term.

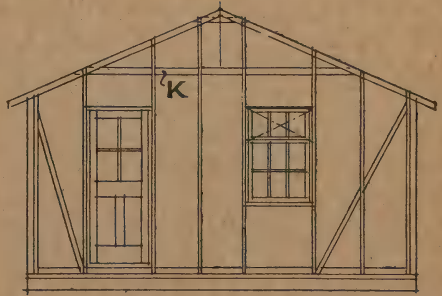


Fig. 5.—Door-end Elevation of Bungalow

The Plan.—A very simple plan has been adapted (Fig. 3). It is one that has worked out well in a number of cases with which the writer—himself an architect—has been concerned, where it has been adapted from army huts. The door at C gives access to a kitchen fitted with self-setting cooking stove, sink, larder, copper or boiler, and a bath, covered when not required with a lift-up table-flap.

Through the kitchen is the living-room with a suitable stove, and beyond are two bedrooms, one larger than the other. Should a tiny third bedroom be required, it can be made about 6 ft. wide and cut off the end of the kitchen.

A better course would be to adopt a somewhat larger plan as in Fig. 4, which has also an advantage in the shape of a separate front entrance and hall. This can easily be arranged, and other variations can be evolved to suit special cases; but the example in Fig. 3 is advanced as an easy and cheap scheme likely to appeal to the majority of readers. Outbuildings can easily be contrived; in the plan shown they consist of a fuel-store and earth closet, separated from the main building by a small yard, which in Fig. 1 is shown roofed in, this being a very useful arrangement.

Clearing the Site.—Having settled the exact position of the building, the surface should be adjusted so that water will trend away from it on all sides. The turf and top vegetable soil should be removed and the whole covered with a layer of about 4 in. of dry material, such as ashes, breeze or gravel, and if this can be rolled and well brushed over with tar it will be all the better. Of cou se, a layer of concrete has advantages.

The Base.—The best form of base to the structure would be a half-brick wall set in mortar on a 4 in. layer of concrete 8 in. wide; but old sleepers might be used and tarred, while on an uneven site it might be worth while to consider stout

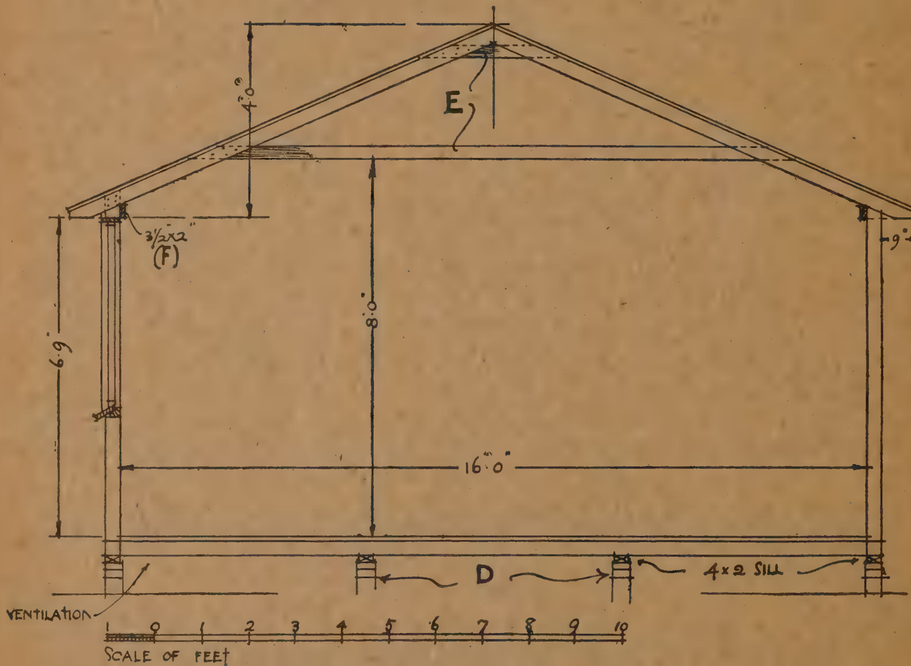
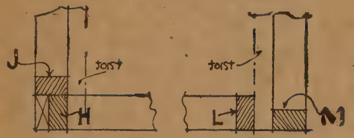


Fig. 6.—Cross Section through Bungalow

creosoted posts with beams or sleepers laid across and strongly spiked down. Whatever the method selected, it is essential to provide a level platform of the same outside dimensions as the building, together with two intermediate longitudinal supports, as at D in Fig. 6, to take the floor joists, and it is desirable that on the whole of the top surface of this be laid a strip of one of the many patent bituminous damp-course materials on the market, well lapped at the joins. Small openings should be left at the front and back so that the under side of the floor may be ventilated, otherwise dry-rot will set in.

Framework. — The framing of the actual building, if carried out as suggested, will be found one of the simplest parts of the work. The first step is to set in position a 4-in. by 2-in. sill on the line of the four outside and two intermediate walls. On this is erected a series of frames, one of which is shown by Fig. 7, while its exact dimensions may be gathered from Fig. 6. These frames are put together on the ground and lifted into position. Each one consists of two $3\frac{1}{2}$ in. by 2 in. uprights, connected at the bottom by a 4-in. by 2-in. joist and at the top by two $3\frac{1}{2}$-in. by 2-in. rafters, held in their turn by long and short collars as at E (Fig. 6). These are merely carefully set out and cut, and then heavily nailed together, no jointing whatever being required.



Figs. 8 and 9.— Detail Sections at A and B (Fig. 3) respectively

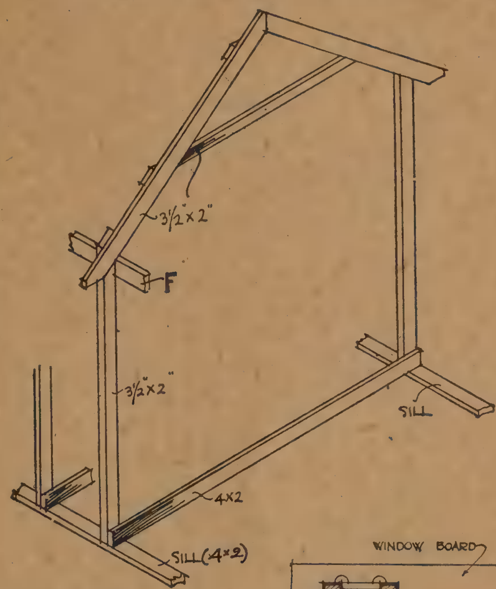


Fig. 7.—One Unit of the Bungalow Framework

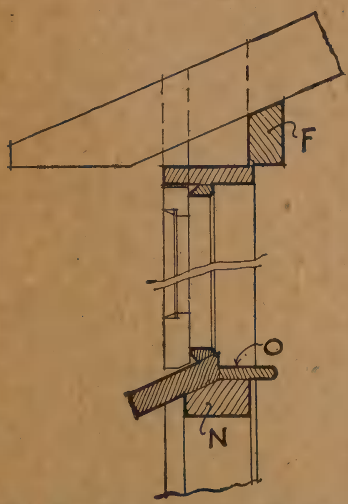
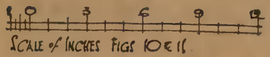


Fig. 11.—Section through Window Head and Sill



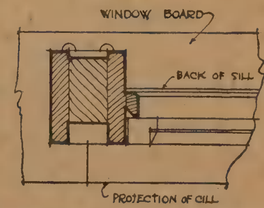


Fig. 10.—Detail Section through Side of Window

When several of these frames are ready they are temporarily braced diagonally so that they will not rack out of shape, and lifted into position 2 ft. apart, measured centre to centre. This work should not be attempted in windy weather. It will be necessary to plumb them and hold them vertical with temporary struts or braces from the sills, and pegs driven into the ground, the permanent fixing being then applied in the shape of a 3½-in. by 2-in. longitudinal member as at F in Figs. 2, 6, 7 and 11, splayed on the top to suit the slope of the rafters, and strongly screwed to every upright.

Before the temporary braces are removed a part of the roof boarding should be put on to stiffen the whole, and the frames should be very strongly secured to the sill by means of a 4-in. nail put in on the rake from each side. A careful inspection of Fig. 2 will show that in every case the frames have the floor joists and rafters fixed on the right-hand side of the uprights, thus simplifying the general setting-out considerably. It should be noted, however, that the tie at G only must be fixed on the right of the rafters to clear the studs forming the ends.

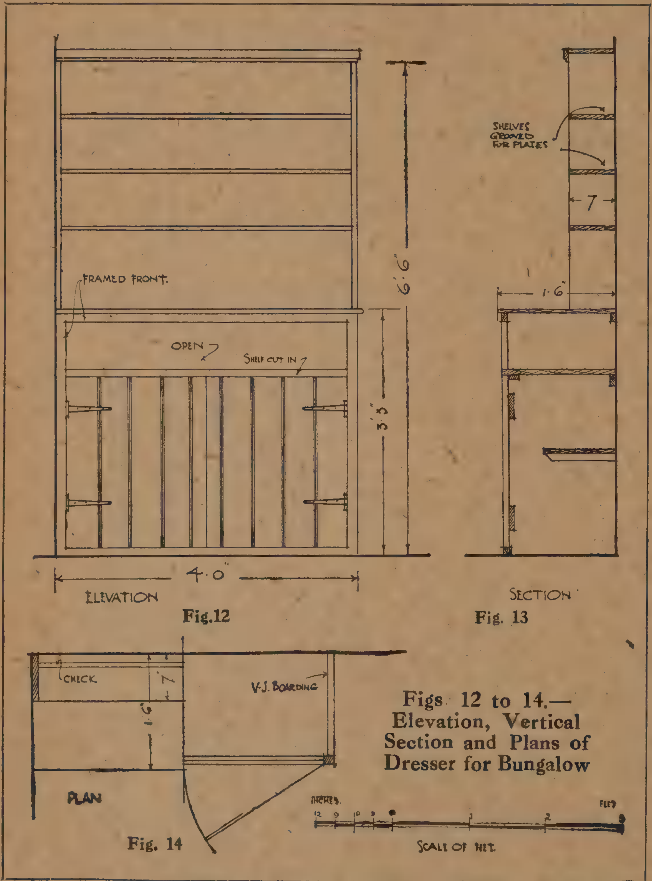


Fig. 12 Fig. 13 Fig. 14

Figs. 12 to 14.—Elevation, Vertical Section and Plans of Dresser for Bungalow

Studding. — Once the frames are up no time should be lost in getting in the end-studs. At the left, where the extreme left-hand upright at the front will be as at H in Fig. 8, the outermost studs for the ends will be as at J, and it will ultimately be necessary to fill in the angle with a 3½-in. by 1½-in. strip, as marked by a diagonal cross. The intermediate studs on this end must be set out as in Fig. 5 to suit the sizes of the door and window. They run from the sill to the raking line of the roof, and should be nailed at top and bottom and to the tie K (G, in Fig. 2). At the other end the studs are spaced out equally as on the plan (Fig. 3). In this case the end studs of the front and back will be as at L in Fig. 9, and the outermost one of the ends as at M, as the last floor joist will come between them.

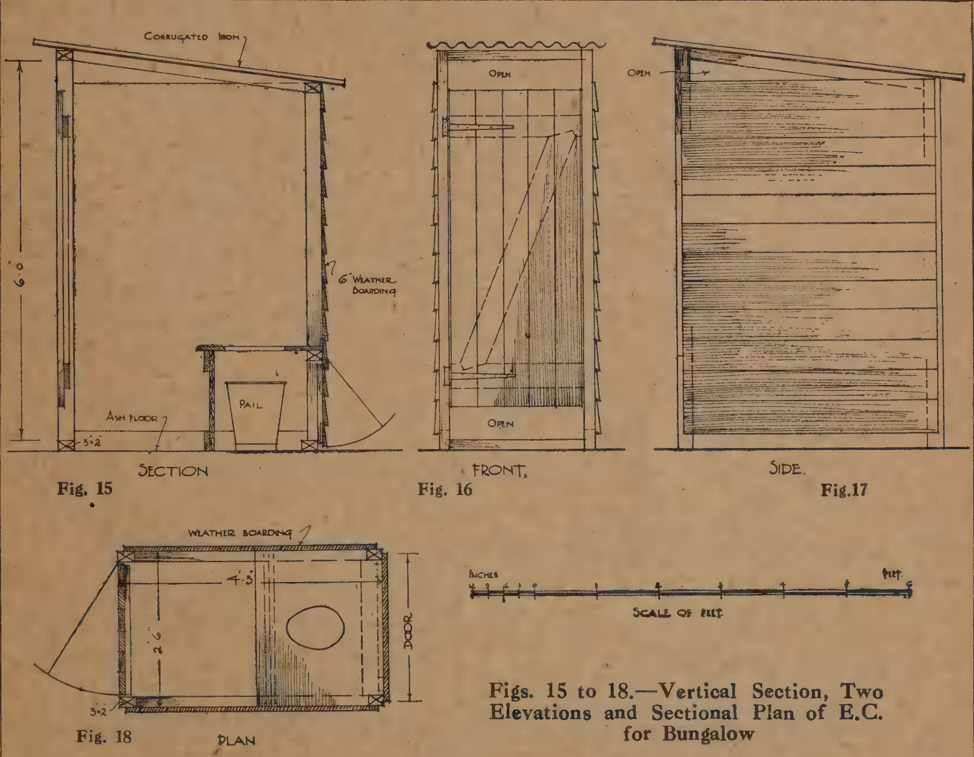
The next step should be to cut in sloping braces next the angle posts on all sides as in Figs. 4 and 2. The internal partitions should be constructed of studs fixed about 2 ft. apart; the transverse ones will be found to come directly over floor joists, but the floor should be laid first,

Windows.—Figs. 10 and 11 give details of the windows, which consist of ordinary light sashes in square linings at sides and heads, and a stouter sloping board as a sill. They should open outwards and have chamfered beads all round as shown, bedded in red-lead and closely bradded. A rail, as at N, tightly butted between the studs serves to support the sill and the window board O. All the doors should be treated in a similar manner, but it may be as well to put an oak threshold to the entrance.

Roof.—As it is intended to leave the rooms open to the roof, this should be laid with tongued boarding, which should also be used for the floors, and the verges should be finished with an extra rafter fixed on the face as at P in Fig. 2. The roof may be covered with good tarred felt, or preferably one of the recognised better-class materials such as "Ruberoid," or, better still, with slates. Asbestos-cement sheeting may also be used. The eaves may in most cases be allowed to drip, unless it is desired to collect the rain-water.

Walls.—The walls can be (1) weather-boarded and stained or painted; (2) lathed and finished in cement plaster, or (3) covered with large sheets of asbestos-cement. The last two alternatives are operations on which expert assistance or full advice are essential to the novice.

Internally the walls may perhaps be left unlined in parts such as the kitchen. The best course is to cover them with "Fiberlic," "Beaverboard," or some other recognised lining, unless plaster can be adapted. These boards can be made to look very well indeed when the vertical joints are covered with small fillets. If



Figs. 15 to 18.—Vertical Section, Two Elevations and Sectional Plan of E.C. for Bungalow

the under-side of the roof-boarding is sized and varnished, this will make the most durable job.

Doors.—The doors can be stock panelled patterns or ledged and braced, and the larder can be formed of V-jointed and tongued boarding with ventilating opening filled with perforated zinc. The draining board and hinged table top over the bath call for no detailed explanation.

Hearths.—Sheet-iron hearths of ample size and turned up round the edges are necessary for the stoves, which should be backed with iron or sheets of asbestos-cement and have iron stove-pipes kept quite clear of the woodwork through which they pass. Each pipe must have an iron plate to stop the opening, and a proper collar to ensure a weatherproof job. Any bends should have cleaning doors. Figs. 12 to 14 show a suitable dresser.

Sink, Bath, etc.—The sink and bath can have 1¼-in. waste pipes discharging to a removable receptacle outside, an open trench in the ground, or preferably a line of drain consisting of socketed pipes laid without cement joints. The earth closet and coal-shed should be of half-brick walling, or framed up in wood, as in Figs. 15 to 18.

A Rack for Brooms

The rack shown by Fig. 1 consists of a stout shelf having a number of slots into which the brooms are slipped. The upright board against the wall has a number of hooks screwed on it. Fig. 2, a cross section, shows the three component parts—shelf, back and bracket. The first should be at least 9 in. by 1 in., 2 ft. 8½ in. long, with rounded front corners, and have four 4½-in. by 1½-in. slots 5½ in. apart, as shown in Figs. 3 and 4. It is

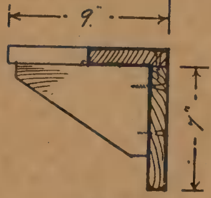


Fig. 2

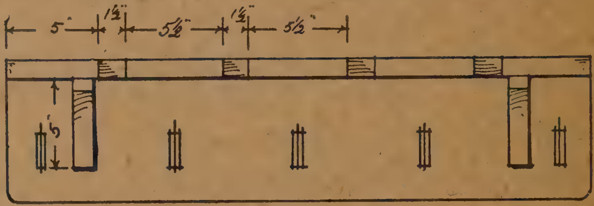


Fig. 3

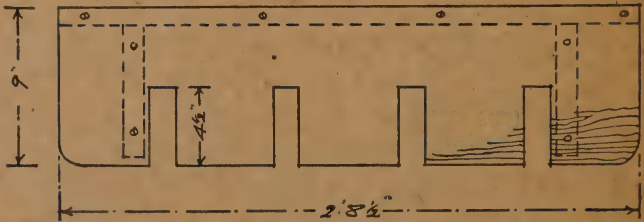


Fig. 4

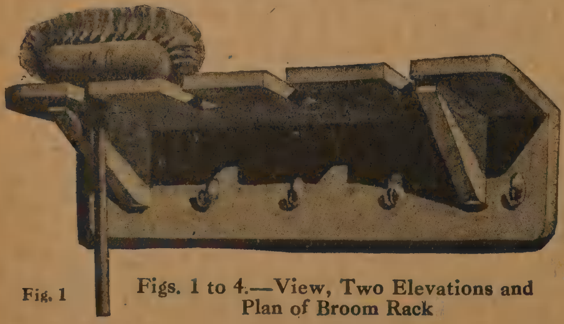


Fig. 1

Figs. 1 to 4.—View, Two Elevations and Plan of Broom Rack

screwed down to the top edge of the back piece, which is 7 in. deep, and is further secured to the shelf by means of two brackets 7½ in. by 5 in., and 1 in. thick, firmly screwed to the shelf and back, ¼ in. from the end slots. The rack is screwed to the wall, the ideal method being to use Rawlplugs.

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Jones
The amateur mechanic